Interview for NASA Aeronautics Scenarios

Name: Total
Title:
Location:
Date:
Interviewers:

Questions

1. It is 1980. What is the aeronautics industry like?

The military is the aeronautics driver
We are transitioning to affordable air mass transit in the commercial world
American dominant market now has Airbus as competition

Looks like a period of reasonable heath.
Balance between military and civilian in industry.
Junction of commercial products being just spin-offs of military products and commercial products being developed from scratch.
Airframe Manufactures starting to tell engine manufactures what types of engines are need, not building airframes around existing engines.
Market driver: technology push - not market pull, efficiency was a driver (oil embargo fears)
Defense drivers: stealth, number of buys, airframe manufactures make profit on spare parts.

The industry was coming out of the problems of the 70's. Starting to get into more international teams. Competition is starting to come out of Europe. There has been no down sizing in the industry yet.
Not many are currently interested in technologies that influence cost and time to market.
Airline deregulation is starting to change the airline scene with the growth of start up airline and the loss of a few.

Airline deregulation had started, airlines were starting how to control their industry by scheduling, managing cost and route structures.
Military: A build up was underway and the military was becoming much more professional.

Industry growth was focused in the fixed wing market because of a strong infrastructure and growth in propulsion.
The helicopter industry was focused in the oil and mineral research and some emergency medical services.
The Bell 206 was the most popular helicopter and the Boeing 727 was the most popular fixed wing aircraft.

Military: Initial stealth designs were starting to come of age, technology is being driven by systems (avionics) and stealth, and the aerodynamics of military aircraft is being shaped by stealth and the fact that the aircraft were becoming more of a weapons platform and less of a dog fighter (performance). There was also a shift in aircraft design from supersonic technologies back to transonic/subsonic technologies. Dominated by the Cold War, government contracts were flowing with out a lot of pressure to produce.
Civilian: The commercial market place is being driven by performance, CFD is coming of age, this is the birth of CAD systems where engineers started to move away from drafting tables and towards a paperless office. The general aviation industry is starting to have sales drop off.

Getting more complicated because of the introduction of the Airbus. Primary players were both US and Europe.
Military: US still leads but there was some competition from Europe, Cold War was still driving research and industry.

Industry was defense driven with major build ups and cold war fears. There were many more defense contractors.
The GA industry had just passed its peak.
Commercial aircraft manufactures were robust.
There was very little concern for "Corporate Welfare".
There was strong support for defense and R&D spending. The energy crisis was still influencing designs.

Had very little interaction with the commercial airframe manufactures but their focus was on subsonic transports. There was still a lot of military research and development. Computational Fluid Dynamics (CFD) was just starting to influence the aeronautics industry.
Domestic industry was leading the world and was not teaming with NASA because of fears of loosing proprietary technical developments.
Military airframe manufactures were the only group that was willing to take risks and push the envelope on applying new research to airframes.

Growing markets based on the expectation of a boom in the Pacific rim, also the start of foreign partnering to guarantee market share.
A great potential in structures growth, composites fuselage components, the "golden age" of composites and NASA is there to supply the technology to the airframe manufactures to make money. This potential has been realized in today's aeronautic industry.
The idea of the industry was to sell more airplanes, not make them cheaper to build.

The commercial industry was in the middle of expansion in the number of aircraft types, the 757/767 were both under development.
In the military the B1 project was coming back to life after it was canceled. Their main thrust was in the performance of the aircraft along with stealth (exotic aircraft).
Competition was starting to come from Airbus.
A build up of new aircraft orders was starting to appear.
US has about 90% (Market share) of transport aircraft.

Certainly the most defining element of the early 1980s was deregulation. It created a new transportation system and a new air traffic control system (ATC).

The year 1980 was a very turbulent one for the air carriers. Many new entrants were active. Air Florida is an example, while Laker airlines is another. These new entrants, however, did not have management skills. They destabilized prices when they competed with main carriers.

Many of the major airlines dropped out of the low density market. They did so because subsidies were eliminated.

Many of us who study transportation predicted what would happen from these developments. Within a few years the new entrants failed, but not before they weakened many of the traditional carriers. We predicted that the number of carriers would decrease to a half dozen. What do we have now? Only seven or eight.

These disturbing trends brought new technical concerns. First, there was a strong pressure to create STOL to meet the needs of small markets. There was also an interest in developing short

haul aircraft. Considerable attention was directed toward meeting the requirements of the low density transportation market.

In 1980 the manufacturers were focusing on higher capacity, lower operating costs, and greater range. But today we also need, smaller short range aircraft. In the U.S., rail systems and other fast ground systems are not practical compared to Europe or Japan. We will have a need for short haul aircraft.

In 1980, the air traffic control (ATC) system was in chaos. We had to start developing technologies that would permit a safe efficient system that had fewer controllers. Research was focused in the 1980s on: (1) automatic systems technologies; (2) improved navigation systems; and (3) means of expanding the capacity of the system. Many of the concepts and plans considered in the early 1980s are now being considered again.

Also in the early 1980s we were just beginning to realize that human issues in the air traffic control should be addressed. It has taken 16 years to operationalize some of these issues. I will now tell you what we were not thinking about in 1980. We gave little thought to: (1) on-line data management; (2) on-line decision making; and (3) we did not anticipate the rapid growth in capability of all the information technologies. We were thinking the solutions were big computers and explicit communications from the ground to aircraft.

We had hurdles of technology development before we could consider a more flexible, responsive, and efficient ATC: one was radar. Before we could allow aircraft to fly closer in air space, we had to develop until radar had a two second sweep. Testing and demonstrations took time. Moreover, pilots would not accept any plan until they were convinced it was safe.

Also in 1980 cockpit management and the human response to cockpit design was not given much emphasis.

The military was getting most of the R&D money. Most aircraft firms depended on the military build-up to obtain new technology.

NASA and industry started the NASP in 1982, this program was over sold by NASA. Both NASA and industry were not ready for a project of this scale and a great opportunity for air breathing access to space was lost. Propulsions systems and facilities were not available.

In 1980 the main force shaping industry was fuel cost and the threat of another oil embargo. The industry was wondering what effect another embargo would have. This coincides with the initiation of the Advanced Turboprop program.

High inflation (about 12%) that was driven by oil prices was also a major issue for industry.

Industry cost calculations at this time were driven by fuel efficiency concerns. This was contrasted to other concerns such as production costs or manufacturing efficiency.

In 1980 the situation was this: We had a new administration. It had a proactive stance on military preparedness. It was initiating the idea of a major military build-up. The F-117 was coming down the path. There were new influences emerging for aircraft design. New studies of the ATF (F-22) design were emerging. Altogether there was a broad based push in military aeronautics.

The civilian industry was just coming out of a slump in commercial aircraft orders. However, most of the airline purchases were of marginal upgrades and aircraft and engines. The manufacturers were, however, positioned to expand production. There were indications that

OPEC was becoming more divided and that as a consequence fuel prices would be going down. Thus, civil aviation in production of large transport vehicles was not able to meet a growing new market.

Civil aviation still confronted the disturbing financial threat of law suits. By 1996 the liability issue was not as distressing for the airline firms.

1980 was 8 years after intro. of 747, before 767, before Airbus became major player, colder part of Cold War
the industry was dominated by government investment, government military application, civilian spin off of military technology, optimism re: technology; beginning to think of computational advancement.
There were 10 major manufacturers
There were modestly low barriers to entry
The thinking was dominated by performance of vehicle rather than life cycle costs
The civilian competition dominated by McD and Boeing
Airbus 300 introduced around then, although it was not considered a threat at the time.

The industry had 2 major components: a) civil aircraft manufacturing and derivative design. Business was strong; b) military - not in good shape coming out of Carter administration. There was not a lot of new aircraft design. F-15 and F-16 still in production; not a lot of new aircraft in development.

In 1980 we were coming out of a serious situation in the late 1970s. Boeing was in serious trouble in the late 1970s and just was turning the thing around. Competition from Europe was emerging. Most of the industry had not yet downsized. All the airlines were stressed as a result of deregulation.

Industry emphasis in 1980 was on military issues - things like stealth vehicles, manned fighters and bombers. For civil aviation, NASA was working technology issues, not specific programs. There were a lot more companies in the industry than today, and both the military and civilian industries were pretty healthy.

The commercial side was completely different. Congress' attitude was that if the commercial sector couldn't do it then NASA shouldn't
What drove that attitude? The free enterprise system, commercial aviation was a mature industry which should be able to take care of itself. It's called corporate welfare today. But more sympathy today given the "Japan Inc." factor, and Airbus.

The year 1980 marked the beginning of the current design effort. Aircraft like the 747 came from this design period. Industry was looking toward continued growth. However industry had not anticipated the high acquisition costs associated with these designs. In addition, capacity was a major concern of industry in the 1980s.

The industry was a number of independent entities that were proprietary and would fight rather than work as a consortium. While European firms were forming consortia at this time to work for competitive advantage, the U.S. was not yet doing so. They (the Europeans) came up with a new engine with this process. The Europeans found this to be a win/win situation where everyone contributed to the development process, everyone got a piece of the end technology, and the cost of development was decreased for everyone. Our industry is just now learning to do this now.

The size of the industry and market were different. The industry was just starting to go to a hub based system that was started by FedEx. Hubbing becomes an important factor.

There are the beginnings of a change in emissions and noise concerns that effect engine manufacturing operational parameters.

The industry has been pushing on the same factors forever such as fuel efficiency. Fuel economy was more emphasized in the 1980s than it is now. This was when there was the beginnings of a push for more fuel efficient engines. Some of these fuel efficient engines are entering the market now.

There was some modeling in supersonics in the 1980s. Now the industry is talking about it again. Supersonic technologies may change the paradigm.

Military aeronautics was struggling to win the Cold War and protect U.S. interests.
Commercial aeronautics was in the good position of dominance with very little foreign competition.
NASA was almost unlimited in experimental research.

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Aeronautics in general has been through several phases. The pre-1980 phase involved doing things for the first time; then we moved to the "done thing for the first time" phase followed by "doing them better" phase.
During this period , the industry was driven by performance. Players strove for higher efficiencies which included better fuel consumption levels and better design engines (birth of hubs). Today the industry is driven by cost.

This is the beginning of the Reagan build-up that served as a prime driver for the country's aerospace industry.
U.S. commercial aeronautics has a great advantage over Europe and there are no Asian competitors.
Stealth technology is shaping the industry with the beginning of a black world. Black world activities drive military aeronautics.
The advantage the commercial airline industry held at this time was detrimental to securing funding under the Reagan administration. The perception was that an industry as mature as aeronautics did not need additional support. If a lab had to be closed, commercial aeronautics was at risk. NASA Lewis Research Center was at risk.
It was a dark, depressing time, but some good came of it later. It generated more thought about the role of NASA aeronautics. It started the supersonic commercial aircraft drive.
Aeronautics was not emphasized during the early 1980s. This is exemplified by the saying "Aeronautics, the little a in NASA." This was especially the case for the budget.
Survivability at Lewis depended on tying Aeronautics to Space. Aero tied itself to the space station and saved itself.

Europe is just emerging as a aeronautics power. Boeing and MACDAC are the key competitors. Excess product and production capacity in planes and rotorcraft after Vietnam War. Military build up in US just beginning which provides for robust engine development and a good production base for aircraft venders and integrators.

Low taxes in US with plenty of consumer confidence. The Japan bubble economy is just heating up. US interest rates are being kept artificially high which raises the cost of capital in the US. The unanticipated consequence is that the Europeans get a window of opportunity to develop

their aircraft industries. Manufacturing and distribution are becoming global as the electronics industries are exploding on the scene.

US auto industry in trouble and the US stops being seen as a closed economy. Airline restructuring is in full swing after deregulation. The era of US power in bi-lateral negotiation is ending. European industry is slowly "Europeanizing." Russia is emerging as world class in materials technology while China remains a backwater, with no significant economic reforms. The South American financial crisis effects perceptions in the US of the wisdom of investment abroad.

The Concorde is flying. Communication is low bandwidth and IT and comm. technologies would not support the kinds of control technologies we use today. The mainframe to PC shift has just begun. Manufacturing and products are moving down in scale. The value of "small" is being recognized. Niche products and micro manufacturing are emerging. The ATC strike affected NASA goals.

In 1980, airline deregulation had a major impact. There was financial uncertainty. The airline business went from years of profitability to uncertainty and losses after deregulation. There were five years of losses following deregulation. Deregulation changed the way the airlines did business. There was a major shake-out. The market for commuter aircraft increased. This permitted Brazil and others to have a market in the U.S.

Deregulation stimulated major changes
Competition on fare rather than service
Technology driven by service - changed to economics
Needed to develop commuter aircraft to serve short haul situation
VSTOL technology for military - cyclic funding
NASA Aeronautics research funding was stable
High GA production
Noise reduction - aircraft efficiency program

The Aeronautics industry was dominated by large US transport aircraft. The Airbus was just getting started. The NASA mission was based on aircraft that flew faster, flew higher and had a longer range. The Cold War was still on and the military mission was dominant.

The industry from a military standpoint was good for engine development. A task force was looking at NASA Aeronautics' work because NASA was considered by the Administration as going out of business. Program through which NASA could re-enter the aeronautics field: return to the work it was doing prior to space work.
The types of programs proposed :

- support for commercial propulsion programs to improve current commercial planes;
- program to look at reliability of engines for commercial planes. This played a major role in providing technology for engines on current commercial planes.

The industry is evolving from first generation of commercial jet transports to a second generation of quieter, sophisticated, customer focused transports.
There are new applications in the industry, FedEx.
The current generation of jet fighters were coming on line, F-15, F-16.

General aviation is about to enter a steep decline in manufacturing. This rise in sales in the 70's was seen as a supply side boost rather than a market pull. There is no new technologies in the aircraft being produced. Manufactures are relying on World War II type technology and their pricing is out of sort with the product they are selling. There is no foreign competition to drive

price or development. One of the key reasons for the decline in sales was the increase in other recreation pass times. People were spending their money going skiing, sailing, etc...

Commercial products were in a state of refinement. Every major development in aircraft has come on the tails of a propulsion advancement, airlines after jet engines, and would like to see this type of event happen in the small aircraft industry.

80s not much different than 90s in aeronautics - deregulation began to have effect on the airline industry, FAA was in better shape then (not now). FAA had a leader reputation as did NTSB nationally and internationally. Not so today (e.g. Value Jet, Venezuela). NASA mission was not very evident. Materials was one known area. Center Tracon Automation System a good effort. Human factors was a prime effort. Safety reporting was good. There was a good rapport between government agencies. (2) Today politics has overridden this rapport. Industry and government are also the same today.

The commercial industry was in a comfortable healthy growth. General Aviation was in a boom. The industry as a whole looked like a strong growing field.
DOD was a major sponsor of products that could be used in by the civil aviation industry.

Military side - Reagan cold war - develop new weapon systems - enhance capabilities B-1s 100 copies short term - stretched thin short fall of engineers because competitors were also stretched thin - 1/2 of the airplane was outsourced - Martin, GE, all US companies, etc.

- USAF was the integrator - airframer primed other airframers
- O&M should be privatized - industry losing industrial base by not doing O&M - Low rate buys story of future - low surge capability can be changed to high surge.

- Right after deregulation and controllers strike
Great upheaval as change from stable regulated industry
New equipment mandated by rules
Routes were stable
Competitive practices emerged - awakening of industry
NASA - LOFT, CRM, use of simulation, glass cockpit
Death of SST
More emphasis on safety rather than operations - more efficient airframes and engines

The rotorcraft industry was emerging from a successful military and civilian market and in the 80s began to rapidly diminish.
Some reasons include:
- Iranian market went away
- Oil became cheaper thus diminishing the need for offshore activities
- Foreign military market went away
Results included;
- industry downsizing
- more balance between military and civil markets
Less capital available for R&D

From a military point of view, aeronautics bounced to its low point. It was starting up slow again, then Reagan came in and accelerated the pace. However the pace was still not compared to the 1950s tempo.

There were several demonstrators in the mid 1970s, turned to systems in 1980s.

Money was strong for aeronautical-defense—DOD. NASA focused on helicopter development because of the integration of labs, army etc., near NASA. The prototypes tended toward the military.

1980s were an active time: the Cold War was in full thrust and there was concern that we had let our forces deteriorate post Vietnam.

On the commercial side (admits he doesn't know too much because he's concentrated on the military side): Boeing was recovering and bringing in the 757 and 767, they went through hard times on the 747. McD was doing well with the F-15 and F-A18.

In a nutshell, it was a relatively healthy Cold War period.

Douglas, Boeing airbus was threatening. Reliability of ETOPs was the major concern. Douglas trying to catch up with the MD-11. Commuters were trying to determine if there was really a viable market. Was the aircraft driving the market or vise versa. Engineers were not totally optimized. Optimization took place later. Avionics in the learning stage. Too much built interest. Industry unhappy with micro processors. System engineering weak point still is in the commercial market. Douglas shares design in the outsourcing - Boeing doesn't. Enables lower costs.

The Concord was an issue and there were high hopes for high speed, economical travel. However, analysts were beginning to see environmental and economic costs that had not been anticipated or planned for in high speed travel. High speed travel developed the reputation of being a form of elite travel: kind of the Orient Express of air travel.

Medium bypass ratio engines were beginning to emerge. Engines look different.

The 747 was the largest plane and it was a novelty. Planes were getting bigger.

There was a common view that the aeronautics industry was mature and at the end of the line. There was no vision for major change.

A bullish market was envisioned with lots of growth that did happen, however there was still over-production.

In the U.S. market, Airbus was a joke. No one believed it could field a competitive/superior product line.

There was lots of complacency and expectation that the current situation would continue.

Noise and emissions issues were just beginning to be considered. There were few urban areas around airports so noise was not really a factor. No one thought about the ozone layer or global warming as credible problems. Work on the E^3 began due to emerging worries about the environment. The engine was being explored, but no one expected it to enter the market in the next 20 years.

There was always a push for efficiency due to the range/payload tradeoff. This push for efficiency was independent of the oil embargo concerns. There was only limited commitment to improved fuel efficiency. Fuel prices had pretty much stabilized by this time.

There was an understanding that larger engines would be needed for stretch planes.

The industry could sell aircraft for a reasonable profit using existing techniques and technologies.

- Aviation Industry Highlights
    - Hope for jumbo jet (747 New)
- SST Lingering debates about supersonic transport (US backed off by 1980)
- More alternative futures on table
- Debates about shuttle, critical platforms, space station, unmanned exploration of universe
- Creative tension
- Nation's love affair/pioneering spirit with NASA and space had waned
- NASA had a hang-over competition internally-aeronautics & space (aero folks lost)
- Later planet earth
- NASA had put emphasis on space side but had not winnowed down choices
- Still had general aviation industry
- Had NASA interested in tiltrotor (civil) and low speed flight
- US centered perspective WRT industry
- Had not gone thru downsizing/mergers
- Industry more competitive than today

- Systems Engineer - how digital computers could be used in airplanes

- 1980s - Technology driven era both civil and military. Cost was not a problem Super critical wing - first for speed then for more fuel holding.
- Stealth became a player during this time.
- Flight research organization - shouldn't be limited to air breathing.
- Aeronautics has done more than aeronautics space shuttle work was done. Software research also.
- Military flows down to civil - performance based research.
- Roles and missions - Dryden - high speed research.

What was aeronautics industry like. Boom years - more work than we could do. 1.2 billion dollars were wrote off on F-20. Government decided to sell any aircraft to foreign powers (i.e., F-16 and F-15).

- DOD was the big market. Stealth technology was the inroad.

What is the aero like - Industry was emerging into new technology - specifically the military. Were starting to use same technologies NASA had already developed like fly-by-wire. NASA assisted in the transition to these technologies. Customer needed it for improved performance. Super critical wing is another example. Cost of fuel wasn't the driver, efficiency, performance, reliability were the prime reasons for pursuing new technologies. Advanced control technology was the thrust at this time.

In 1980 we were in the throes of early deregulation with lots of airlines and lots of choices. These were the Reagan years with a strong defense and economy. Space was predominant at NASA with areonoutics a poor second. This was an era of robust profitable airlines with astrong budget for defense.

Military aviation is robust F 14, 15, 16, 18 in production
Military industry McDonnell, Douglas, Northrup, Grumman, General Dynamics, Lockheed, Boeing are all healthy and producing aircraft.
Civil industry also robust and producing
Cold war is on and R&D is strong

The military had lots of projects, and money. Performance was everything, challenging. We'll never see the era of the 1980s again.

General Aviation was undergoing a boom in production and operations. Airlines were about to enter a big recession.

Industry - Product demand particularly military was very high. GA and product liability was a major issue. single pilot IFR work by NASA and human factors were NASA efforts in the GA community. Deregulation had an economic impact because low fares caused a lessor demand for GA aircraft and GA operations.

Industry was very conservative. DOD was a strong driver in the market place.
Airbus was being started in Europe and the newly elected Reagan administration was beginning to pump money in to the aeronautics industry.

Small number of players with Boeing and Douglas dominant, developing next generation aircraft.
Inititial dereulation was started Braniff was an up and coming airline

Robust environment, large programs-atime of healthy successful organizations

There was a lot of aeronautics development; the industry was coming off a large build period and was pretty comfortable with their forecasted future; there were a lot of companies doing aeronautics type work on both the military and civilian side.

Outlook was rosy by industry and NASA. Budgetary commitment for NASP, unlike today.

Exciting times and everything was booming. The 60s and 70s were great for helicopters and the begiining of 1980 continued that trend. It was also the start of the downward trend . Carter initiated the downsizing of the military

What is the mission of NASA Aeronautics?

High Tech venture development
- Classic R&D
- Materials development
- Broad scale Research to support improvements in Aeronautics

NASA had freedom to development its own mission

The mission was relevant to industry needs. The ACE (AirCraft Efficiency) program was driven by the oil embargo.

Focused by technology thrusts; they are aligned with the military industry, commercial and rotor craft.
Did not have as many focus programs as today, performed more basic research , and there was no pressure to pursue technologies that had a direct effect on creating jobs.
Causes: The roots of NASA aeronautics run back to NACA which was more a basic research organization but political pressures have forced the change toward more focus programs where job creation is now a driver.

There was a lot of space work being done by NASA. The were being driven by the Cold War and enjoyed strong national support. They were excelling in the space business.

NASA means space.

NASA was strongly supporting the military, it was supplying computer cycles to industry, super computers, for use in CFD, and wind tunnel facilities. There was not a lot of effort towards general aviation. Commercial aviation was being supported by supplying wind tunnel facilities and computer cycles.
The key drivers for the research was the Soviet threat on the military side. There was no real competition on the commercial side, they were begin to get sloppy on there research on design.

Carried mission from the past; still developing both military and civilian technology.

Find practical solutions to the problems of flight. Have focus on the flight area from Mach 0 to 3.0. Decisions were not as highly politicized as they are now.

Research associated with the military to help put down the Soviet Union and to be a friend to the smaller manufactures (general aviation). Also, do the research that no one else in the world could do.
During this time frame, there was little control on research, a lot of little projects filled the agency. There was a lot of competition among centers. "ACE" was winding down and there was not a lot of focus in the agency.

To be out in front of industry. Have the technology ready when industry catches up. NASA must have a longer term out look and invest in the long term in technologies.
What drives the mission: "ACE", driven by the Arab oil embargo, composites were targeted because of weight.

NASA mission in this time frame was 75% high performance aircraft research or military supported research. Technology validation was not looked into enough at this time.
Research areas that have proven to be fruitful were: CFD, energy efficient engine cores, aging aircraft and NASA's facilities. (Comment: NASA Research takes 10 years for industry payoff)

NASA was mostly pursuing joint work with the military. There was minor FAA related research. The research process emphasized basic research with a long-term view.

There are cycles of NASA support and NASA missions: sometimes there is a long-term view and sometimes it is concentrated on near term problems. These cycles are mostly related to changes in administration. It is important to recognize this cyclical nature of the industry as well as the need to push into new areas. Several pendulum swings effect the industry including: short vs long-term focus; military vs civil applications; basic vs applied research; and in vs out-of-house approaches. NASA does, and should, act as a stabilizing influence on these pendulum swings with a balanced R&D program. Two examples from history are the SST=>HSCT and VSTOL=>ASTOVL research. While the industry interest in these two areas was minimal, NASA continued a low level of research effort and served as the repository of knowledge while industry forgot the lessons learned.

Sometimes the past is the future. We may want to re-examine the NACA approach to research and get some of the Old Guard involved in the process.

The mission for NASA propulsion research was to finish development of the energy efficient engine for the commercial arena.

In the military arena there is stagnation because of Carter's F-117, B-2, and ALCM programs. Military aeronautics R&D focused on higher, faster, better: which was not necessarily becoming

a major element for commercial industry. Underground development was becoming the background for aeronautical development. There was tenuous military/ NASA cooperation. He stated that it is clear now that there was a lot of money spent in the foreground for small future returns. However he feels that many of the behind the scenes technologies developed at this time paid off.

NASA's mission during this period was essentially to (1) pursue basic research; (2) work closely with DOD and industry in addressing problems of current systems; (3) national missions such as helping to create more fuel efficient aircraft; and (4) validate new technologies.

In the early 1980s, however, NASA Aeronautics came under attack. The Heritage Foundation announced that aeronautics was a mature industry in the U.S. Consequently, U.S. firms did not need further funds or technical support from NASA. The Agency was under considerable pressure until 1982, when DOD said NASA was needed for its aeronautics experiments. We had to worry throughout most of the 1980s that if we got beyond basic research we would be slapped.

Confused—and still so today
Two major transformations in last 20 years: 1960 NACA, predecessor of NASA, knew its mission—partnership with business.
1960: the mission was corrupted by the shifting of all assets to the moon—the space mission
1972: back to aeronautics
NASA was the leader in aeronautics in 1958. It lost its dominance in the field by 1972, because of the diversion of efforts to the space mission. So when it was told to go back to aeronautics it found itself at a disadvantage.
NASA had few pockets of technological capability: wind tunnels, high strength composite materials; Ames: computational fluid mechanics (NASA is still doing this)
By 1980, the Lewis research center was not contributing to gas turbine engines—it lost its edge.
In a nutshell: In 1980, performance was the driver of the industry, the industry was US dominated, NASA was involved in a technological race to try regain its traditional role it had in the 40s, 50s and 60s.

NASA Aeronautics mission was heavily oriented to military aviation technologies, and cooperatively working with the Air Force, Navy, and industry, while heavily involvement with HST and ACE [?] energy efficient aircraft activity was declining. Some airframe work was taking place.

The aeronautics mission evolved during WWII and cold war, where the mission shifted from civil to military after NASA was formed in 1950's out of old NACA. X-wing and swept wing came out of NASA. In 1980 we were coming out of the energy crisis. Oil was flowing again. Aircraft manufacturers didn't see need for fuel efficient aircraft. Russia was still a threat. We needed superior aircraft performance. Security involvement became part of aeronautics.

The mission of NASA was primarily shaped by the response to the military threat. The primary research missions were: (1) rotorcraft; (2) increased transparency; (3) propulsion; and (4) other technologies which enhanced performance of fighters. In 1980 we devoted more effort to basic research. We had many small research projects rather than the mega programs of today.

The focus on basic research has a long tradition dating back to the old NACA.

NASA Aeronautics mission at that time was heavy into NASP, hypersonics, and had a heavy military emphasis. The mission called for the development of basic technologies, and wasn't focused on particular aircraft. The mission at this time was driven mainly by the cold war.

NASA Aeronautics was asking where aeronautics was going, they were always searching as to what was the mission, what was their role—aeronautics was not high on the agenda at the time.

NASA Aeronautics was worried about the future of NASA, should they go back to their origins (back to aeronautics as opposed to space) or should they just ask industry what they want to do. NASA needed to worry about Air Traffic Control (ATC) because without ATC, markets are restricted. Constant irresolution between role of government vis-à-vis commercial sector and R&D. NASA was in trouble because it couldn't define its goals. However, NASA was saved because of the tradition that NASA should be doing aeronautics research for the industry .

In a nutshell: NASA was in transition in the 1980s.

The external environment in 1980:

- In the late 70s early 80s the US was entering an era of limited war, so more political instability, fragmenting, and the military was moving from strategic to tactical thinking—issue of strategic mobility was more important.
- Reagan → present: competitiveness is the issue, industry/public partnership

Government role in industry was constantly fluctuating.

Landing fees are an issue—they affect affordability because they vary between countries. Ex: to land a small private plane in a small town in China costs roughly $50,000.

Since the space program came into NASA, where aeronautics fits in the organization has been in flux, all you have to do is look at the NASA budget to discern that.

1980, NASA was in the early development of aeronautical human factors research. The industry realized that human error and management was the largest single issue to be dealt with regarding safety. The next big step was to deal with human error because it was the largest factor involved in accidents.

In 1980, NASA's role was to support the military. NASA was turned to by the military because such work was easily justifiable by Congress.

NASA's mission was oriented toward completion of fluid dynamics. Large computers and their impact were also important. An interest existed in rotocraft for inter-city transportation.

One of the main influences in the world then that drove the mission was the growth in air travel. However, then the issue of how to handle the increased traffic flow arose. In addition, making air travel more cost efficient needed to be explored.

NASA was working with individual industries to develop technologies to develop an engine or airframe that offered the desired performance characteristics. There was a large gap between providing technology and its actual use. Now NASA is looking for cost sharing to indicate industry's interest in the technology to alleviate this gap. Refitting costs a lot. This can keep technology from getting into engines.

NASA and the industry must take technologies far enough to make it less risky to incorporate new technologies.

The basic technology program scale used in Space whereby technologies progress from level 1- the basic concept to level 10- application of the technology. Industry must move technologies through the flight demonstration phase. The fact that some Aeronautics "folks" are adopting this type of technology approach which is helpful to both Aero and Space. It is helping to bridge the

language gap that exists between Aero and Space. The two must be able to communicate with common terms to get joint funding for both sectors. The NASA organization is now starting to work to bridge this difference in vernacular between the two sides. Currently, the work structure is even different between Aero and Space.

Aeronautics always has the same customer. However, there is a reemphasis on the general aviation market that continues to grow. This customer has always been industry. Industry is sometimes self-serving and NASA must walk a line between the interests of industry and government.

NASA Aeronautics does a good job of balancing the near term with future solutions to problems. It cannot do work that is too generic or "pure" on technologies because NASA's customers do not care about or understand it.

Space's customers, on the other hand, are the other mission centers that always press fixing today's problems.

Overall, NASA must work hard to balance the solution of today's problems with the need to pursue future technologies.

By 1980 in military aeronautics we were pushing the frontiers of what you could do with an aircraft. NASA missions during this time reflected this. In commercial aeronautics, industry was quite complacent. Even though Airbus was becoming a major competitor, there was a strong view in the aeronautics business that we were better. Mostly, the NASA missions were in support of the military. Our budgets for military research were four times what they are today. The commercial sector in 1980 was much more independent of NASA. Industry made few requests of NASA.

When the military research declined as a function of the end of the Cold War, NASA began to align itself with the commercial sector. We asked industry to tell us what it needed. This was in 1985 through 1989. When we started to ask industry for its opinion on HSR issues we created a new set of expectations from industry.

To assist the military in understanding aeronautics systems. The mission was dominated by the military.
To continue to advance commercial systems.

NASA Aeronautics mission at that time was heavy into NASP, hypersonics, and had a heavy military emphasis. The mission called for the development of basic technologies, and wasn't focused on particular aircraft. The mission at this time was driven mainly by the cold war.

The NASA aeronautics mission at this time is in a period of significant reversal of its historic mission. The Reagan White house says that it is NOT the business of government to subsidize the private sector with research. (No industrial policy) Aeronautics research is out of favor. That is happening at a time when the total NASA budget looks like this: $1bill for space comm.; $2 bill for space science; $4 bill for space transport; and $200 mill for aeronautics. There was no separate aeronautics office, but 1/3 to 1/2 of all people are in aeronautics. As a result, everyone worked hard to either shift to space or justify their work as space related. Beyond that, it is the national security tie that keeps aeronautics alive. NASA as a whole is moving away from technology for technology sake.

NASA said its mission was performance. Cost effectiveness was not a major driver for NASA in 1980. But by the mid-1980s, cost was a driving factor. By 1990, NASA started to recognize that cost was a major driver. We must improve performance but it must be at an acceptable cost.

Another major influence in 1980 was the DOD buildup. NASA was a major contributor to the enhanced performance of the military fighter and military transport. The Reagan build-up had major impact on NASA.

NASA had a very large space budget and on the aero side they were providing technical support to industry.

In the late 70's industry told NASA that they no longer need their services. There was a falling out between NASA and the GA industry and from 1975 to 1990 there was no appreciable research done on general aviation aircraft.

NASA mission has been pretty well defined: To provide the under lying technologies for industry to produce good aircraft, example: boundary layer research. This mission has not changed over the years.

NASA Mission. Basic fundamental research didn't do much for system technology. Independent assessments of aeronautical performance. No advancement of key technology - industry no $ for research. Supercritical wing was an accomplishment.

NASA seemed to be concentrating on airlines (specific comment) helped them get more fuel efficient engines
Rotorcraft industry didn't and still doesn't get any help in this area. Existing rotorcraft are built around engines from 1950's technology.
Didn't really know the NASA mission but was certain it didn't include the rotorcraft industry.

NASA's mission was to do aeronautics research that would find its way into supporting U.S. industry.

NASA and industry were not closely coupled. NASA was not viewed as being on the critical path. It was a useful partner, but it was not influential for immediate products. Sometimes firms would use NASA technologies, but they were not interested in working with NASA. Partnering with NASA was good, but not critical. Occasionally, industry would ask for assistance with a problem.

NASA research generated systems that benefitted longer-term issues and were less focused.

NASA Mission - From his perspective doing high risk technology
- After Challenger - Dryden became very conservative
- Ahead of industry in technology

NASA Mission - Energy efficient engines, support military, maintain aeronautics research capability.
- Military - problem solving - wind tunnel work
- Industry - technologists were happy - CEO's were aware.

NASA's Role - NASA supported fundamental research not military stuff. Cooperative programming was conducted quite extensively. General research was provided, specific research was done with DOD to protect proprietary right.

NASA Mission - At Dryden, focus was on providing R&D which would benefit the military. Support to the space shuttle was high on the list.

NASA space is strong but aeronautics is weak.

Mission is not focused.

Support of industry, leader in area of aeronautics. NASA didn't take much credit for military contributions. Reluctance to say it was doing military work because of a conflict with DOD budget. A lot of wind testing was going on.

NASA did not do hardly anything in aeronautics and the thing they did do were not very useful to the commercial and general aviation industries. They were mainly concentrating on the space shuttle.

Lots of research being driven by NASA and the Air Force. NASA was stronger then it is today. They were doing research in the areas of reduced drag, fuel efficiency, forward swept wing, faster cruise, improved maneuverability, thrust vectoring/reversing, new materials (composites), engine components (hotter burn), improved avionics, glass cockpits, human factors in cockpit, and heads up displays (HUD). We are seeing the benefits of all this research today.
Not a lot of working together between NASA and DOD.

Broad based, many targets, not focused, driven by commercial interests

NASA focus was on space with aeronautics taking a back seat; research was being conducted in lifting bodies, stretches of current air frames, better performance, and vehicle management (air frame and engine integration)

Do the exciting and glamorous stuff, real research.
Air line benefit: Specific research that had direct effect on air line industry or requested by air lines, small short term projects.
World drivers: Big dollar government commitment, we could out spend the evil empire.

Explore space and secondarily provide research for transport aircraft

2. How would you compare that to the aeronautics industry of 1996?

Changed dramatically
Must maintain a level of R&D without military
Nation needs High Tech Aero research
Worried that we are diminishing the US leadership position
    Due to lower civilian spending w/o military
Commercial operation research particularly needed as much as the
    former aero research
Air fleet management an issue
    Should be able to track and control all air traffic in the world form the ground
    Information is available
Potential future is Asia, Africa, South America

Driven by business parameters: design cost, airlines, market pull, technology "buying itself" onto an airplane, commodity, competition has changed
Partnerships: more common (airlines, manufacturing, design (somewhat)), risk sharing, smaller players are looking to build more than just parts for the big airframe manufactures (Boeing)

There have been a lot of changed in today's industry, down sizing has occurred, especially in the military industry. The commercial industry has a lot more competition from foreign industry, but

Boeing is still strong, McDonnell Douglas is marginal in strength. Foreign teaming now a must to sell products in foreign markets. There is a lot of pressure to reduce the cost of aircraft. The Military market has almost completely dried up.

Aeronautics is much improved today. The industry has become much safer with a significant reduction in the accidents. This has been caused by the industry taking many small steps to improve safety. Commercial transport companies have increased there productivity, reduced cost, supplying the airlines with a product that is much cheaper per passenger mile. Airlines have also increased productivity in their work forces, however there has been a reduction in the comfort of flying (load factors are much higher and airport are more crowded). The cost to US airlines per seat mile is much better then the rest of the world. Because of the change in route systems, smaller communities have lost some of there serves when compared to the 70's. General Aviation today does not look much better then it did in the 80's when liability almost destroyed the market. The products they produce are just too costly.

Civilian market is flowering, fixed wing is undergoing some consolidation, but retains healthy competition.
Helicopters have matured, the EMS market is strong, with most hospitals using twin engine helicopters. Offshore oil is still a strong market and corporate using is increasing.
Currently there is no successful short haul commuter aircraft.
Today there is a better understanding of what operators need. Industry is trying to reduce both acquisition and operating cost. The military is also starting to focus on lowing these two cost factors.
The military is starting to learn what the helicopter can supply: transport, attack vehicle, scout/recon. The stealth factor is growing in importance. In the 70's and 80's performance was the key driver, today cost is playing a key role in decision making.

The industry is smaller. The military side of the industry has shrunk when the cold war ended and contracts were cut back. There are only two military contractors left, McDonnell Douglas and Lockheed Martin and these manufactures lack creativity and are driven by profit. Industry as a whole is getting leaner and meaner.

Competitiveness in the world market is causing domestic manufactures towards goal that NASA does not understand. Pressure is being applied from Airbus and the Pacific rim countries.
NASA has a more complex problem to determine how to assist industry and develop the technologies industry needs.
Industry is concerned with loosing market share in the growing market place as new foreign competitors are coming on-line.

No longer driven by fears of the Cold War, what we have is a list of annoying states and a lot more economic competition (Airbus).
Military has changed across the board with small purchases and less R & D funding causing a shrinking defense industry.
GA is "in the tubes" but might recover with the changes done to product liability reform.
Government aeronautics is much more politicized with both the Hill and the White House try to micro manage NASA, there is much more competition for resources and real change in political view of research with the introduction of the fear of corporate well fare.

Military airframers are trying to maintain there existence.
Douglas Aircraft is struggling to get new products out the door, this could lead to their death as a commercial airframe manufacturer.
Boeing is a strong player in the world market place.
GA is trying to scratch out an existence.

Airbus took a large risk (made a number of decisions based on calculations and a little wind tunnel data that were quite successful). Airbus is also helped by its strong government backing.
The end of the Cold war is causing mergers of the major domestic aeronautic companies.
The work force is being eroded by the lack of hiring and the lowing of standard in today's universities.

The Pacific rim market has not quite developed as expected.
NASA has come to the rational that a cheaper aircraft will sell. The airframe manufactures are trying to make money, not develop technology.
Airframe manufactures found out that the Pacific rim countries could not be "gee whizzed" into buying a bunch of aircraft by dangling a small part of the manufacturing process .
Airframe manufactures have over estimated demand, the industry is cyclical.
The industry is enveloped in a lot of posturing. Vehicle concepts such as HSST or short haul/tilt rotor will not be built until they can make money on them.
NASA has become more customer oriented, HSR is a near term research project asked for by industry that may or may not be built because of market drivers.

In the 80's the industry was dominated by the military. Today 80% of Boeings business is in the commercial market place.
Today, cost is the driver, while in the past performance was the key driver. Because aircraft manufactures have reduced the number of cockpit crew members and improved the fuel efficiency of the engines, the cost of acquisition has increased in percentage of the total operating cost of the aircraft. Because of this greater percentage of total cost airlines are pushing for cheaper aircraft.
Process technologies are becoming key to total cost. It is important for the right products to mature at the right time.

Today, because of advances in information technologies, free flight concepts have emerged and attract considerable research interest. This concept will allow the pilot considerable decision autonomy and permit two pilots in the same air space to negotiate with each other. But this concept will create a new set of questions for air traffic management. However, while the technology is readily available to implement this innovation in the near term, political processes, reluctance to accept change, human adaptation to new systems, and testing will all slow down the process toward such a system.

In 1980 a nationwide system management was not considered. Today technology makes this possible.

The advanced traffic management concept is a 1996 effort. Today system-wide flow control is a possibility . Nationwide management is also possible. Resources within the air traffic system can be prioritized.

However, today I do not see any really new concepts compared to 1980s. What we have is the emergence of technologies that permit us to deal with issues we have confronted since 1980.

In 1980 the on-the-ground control system was premature. Most accidents were on the ground. However, airfield simulations have improved airport management. Today there is more airport automation which has made traffic control on the ground safer and more efficient.

Free flight was not predicted in 1980. We did not have the information technologies to even consider the concept. Free flight will reduce by order of magnitude the works of ATC systems. It will save fuel and time. The system will actually be more conservative because when pilots negotiate avoidance procedures with each other, they will miss each other by greater distances than when ordered to adjust by an air traffic controller. This system will also be more flexible.

American Airlines did a study called "User Controlled Routes." They claim that such a discretionary system could save the airline industry $1.5 billion in the year 2005 when compared to traditional air traffic control systems.

One big problem "free flight" will have to solve, however, is the density of terminal air space.

The aeronautics industry is in transition. There is more of a focus on civil activities and the military requirements no longer dominate the agenda. There is now much more of a focus on working with the FAA. There is also more emphasis on how we can take technologies with military applications and apply them to civil aviation.

The NASP program died about three years ago, it is now down to about $10 million a year. Industry is just thinking about high mach number vehicles.

Today, there are different driving issues in commercial aeronautics than there were in 1980. In part, he attributes this to the fact that there was no real commitment to supersonics in the 1980s.

Today there is a major national effort led by NASA and the airframe industry to do supersonic air cruise craft to see if economic utilization is actually possible (IE, can supersonic cruise be done economically). It is very interesting that we are now one-third of a century beyond the initial attempts to develop supersonics and we are not very far along in the effort. The supersonic transport was canceled for ozone layer dangers and other environmental concerns.

The environment and economics are the critical factors in developing supersonics. NASA is now trying to get an economically viable supersonic craft in service by 2010.

Supersonics are being driven by the emerging Pacific Rim market. Industry needs longer ranges than are available on the Concord. People are looking for an affordable, "business class" supersonic aircraft.

Industry is looking at full scale hardware for risk reduction. In other words, there are studies that are being done to help "sell" the effort to Congress and financial institutions. This type of informed marketing will be important to the program. Government involvement is also very important to carry the effort because industry simply cannot afford it. The government is helping by doing some teaming, but in other nations there would be a more active support structure in place sponsored by government. The role NASA is playing in the venture is critical.

In the AST program, progress has been effected by changes in government. In the beginning of the Clinton years, there was stronger support in Congress and the President was willing to support the efforts of his party. Now the new Republican Congress is not willing to provide high levels of support.

These types of programs must not be perceived as corporate welfare. No foreign competitors have to sponsor development programs on their own.

AST is one arena where progress would still take place if NASA were not there (albeit at a slower pace.) Also, NASA's presence in this arena is less perceptible.

The goals of the AST program are increasing the range, size, and capacity of the aircraft. The big difference for the U.S. will be to become competitive with foreign industry. If not, Airbus will dominate and we will lose our trade advantage in planes: one of the few positive trade balances for this country.

The major public impact of NASA in AST is environmental emissions and noise pollution. These things will become critical as Europe institutes new laws and stiff penalties for airlines not meeting their pollution standards. This would cause a significant change in Europe and give a competitive advantage to the European aeronautics industry.

A challenge to NASA is to sell the U.S. public on the benefits of AST to the basic traveler.

As the emerging market in the Pacific Rim asserts itself supersonics will play a huge role in serving the commercial airlines.

By the 1990s there was a paradigm shift to how to make government more responsive to customers. There was pressure from OMB and the Congress for us to be more responsive to the need for U.S. firms to be more competitive on the world market. By 1996 Airbus had captured one-third of the world market. Congressmen asked: "NASA, what is the relevance of what you are doing?" Today, we have redefined who is the customer. Moreover, we are more partners with industry than in the past.

Over the last 4 years the priorities have been:

- high speed research program
- advance of subsonics
- facilities upgrade (distant third)—fund the next generation wind tunnels—haven't received enough funds.

High speed civil transport work: from a US competitiveness viewpoint it started as an environmentally focused program for engine emissions, and noise, some sonic boom issues. The research program is geared to 2005—joint NASA/industry—they hope to have the technology developed by 2005 to achieve applicability by 2010. They hope that the technology will result in an economically feasible plane which can compete with any foreigner. **The economics are critical because they have to serve the entire industry.

Why should NASA keep funding the program and not industry?

Because government has to catalyze the front-end research for high speed and subsonics. **Industry is not going to do the initial research, until they see a profit at the end.

Government role: Government needs to take the initial risks: materials, economics

NASA has a clear role in technology development <u>not</u> product development. Industry is working on NASA's technological developments to get to the product development stage.

Economics of engines: don't make money on new engines for a long time. The engine business is not attractive because there is no front end return.

NASA's role: cause industry to do things that industry would not do ordinarily. Industry needs the government incentive .

RE: Subsonics:

1980: in response to the energy crisis of the 1970s was the EQ Energy Efficient Engine initiated by NASA. The effect of NASA's technology was a GE engine almost directly scaled to NASA EQ—which gave GE reasonable advantage relative to the competition.

1996: threats are more economic and business focuses: Ex: Europe: Rolls Royce, BMW combinations; Japan: developed an engine to compete with . New contracts for advanced subsonic technology (AST) will provide a competitive advantage through the year 2000.

**The aeronautics industry is a "razor blade business." To sell engines, have to discount them significantly to stay in the business.

Advanced technology engines are not focused on high performance, but instead only on improving slightly, so as to utilize the technology to build an engine which is competitive and enables a return and maintains US competitiveness.
***Need to build an infrastructure which would permit a transition to high speed transport.

Better engines is not an energy crisis issue—but a broadening of competition in the world.

Environment: noise and emissions has led to a push for low emission engines in Europe, which requires development with NASA of low emission engines. Rolls Royce is strong with new technology programs sponsored by the European governments.

The GE-90 is the first engine developed on company funding. All other engines were spin offs from military technology. **Because of military budget cuts, they rely more on NASA for funding of initial research. For years they were dependent on military funding.

The GE-90 is a refinement of the design from NASA technology. The EQ was a prudent investment on the part of the government. The E-5 has the potential to achieve the same level of significant contribution that the EQ did.

The military uses large transport engines. There is a push toward the military's use of more commercial engines, the military will be relying more on commercial products and technology.

The E-5 would make for a good engine for global transport (Fortress America concept) purposes because it is 20-25% lighter in weight.

Critical technologies: NASA should focus on computational field, because it can be used as a design tool. If NASA had to chose its investment, it should pick computations. Computational fluid dynamics could make improvements in the time to take the product to market, better detection—important to the ability to react to the market to compete. GE relies heavily on NASA's computational work.

The adequacy of NASA's facilities is an issue—the maintenance of wind tunnels.

Propulsion:

Does NASA bureaucracy get in the way of getting engine development work done?

The bureaucracy is a problem, but since LET contracts (??), they have become more practically focused.

NASA has done a good job in reducing bureaucratic drivel—impediments.

Quality of People at NASA?

- they have a problem retaining younger people.
- there isn't a large differentiation with the private sector
- they are anticipating the needs of industry and working with them, so they are moving away from bureaucratic rigidity.
- long-term concern that NASA will continue to be able to attract high caliber people.
- NASA people are every bit as good as those in industry—only maybe a little naïve in dealing with industry issues
- The dilemma is that young people are only attracted to NASA if it's working on sexy deals. The types of sexy/revolutionary ideas which attract good people like the space shuttle are: high speed break through—exciting because can envision it actually

happening, it's risky but sexy (not a farfetched idea); and subsonics, although less exciting.

- Aeronautics is a mature industry, so need to excite young people to get into aeronautics [they need an ER or an LA Law for aeronautical engineers!]
- The E-5 doesn't go fast, so don't get the testosterone appeal of other "fast" technologies.

Income Distribution:

- the high speed aircraft is not an issue of there being a market but rather its an issue of being able to deliver it to market.
- Aircraft sales over the last 5 years: increasing from the Far East, growth of GE in last few years ---its global share has increased
- Can't lose sight of subsonic airplanes (85% of market), because supersonics are only a small part of the market (15%). Ex: intra-Asian travel is subsonic.
- Need for high speed transport is emerging, but not the only solution—another solution would be airplanes with longer ranges to smaller airports, so can alleviate congestion.

Security issue: time spent in airport need to be addressed. Because the plane flight may be only a small part of the overall travel time. Security all fits into aviation now. The present hub & spoke arrangement could be mitigated by long-range airplanes.

How dependent is industry on NASA?

- They are very dependent on far-reaching technological research; on investment into new engines; Because of the synergy with NASA they are able to invest in new engines.

- If NASA pulled its funding: the result would be slow technological development. Industry would be put at risk in its ability to come up with new concepts re: environmental technology, and in its competitive capabilities because it needs NASA to achieve product differentiation.
- NASA's monetary contribution is roughly $50 million up front, but these are highly leveraged dollars. Ex: NASA invested $200-250 million in the EQ engine, which was then followed by a 2 billion GE investment which created $10 billion in sales over the next 20 years, led to 5000 direct jobs, and 10,000 indirect jobs, which led to $900 million in tax revenues. RESULT: NASA's INVESTMENT IS GOOD FOR THE ECONOMY!!! So a modest investment from NASA has a 10 fold multiplier effect.
- If you clip off the front end of the food chain, the industry will become short-sighted.

Industry is not looking to NASA for the product development, only the technological work.

Co XXX looks at quarterly profits!!--not looking out 25 years.

NASA is more confused today than it was in 1980.

- NASA no longer has technically capable systems. To survive NASA must find its way around the civil servant system. Golden created the idea of institutes—so NASA is affiliated with research centers but the centers are run by independent contractors like MIT to move people off civil service rolls. NO group at NASA compares to peers in the private sectors. Private sector/MIT types don't listen to NASA, they don't read their journals.

Why NASA is having trouble attracting quality people:

- low pay
- NASA Aeronautics no longer has the panache of the space agency—it's just another government bureaucracy
- NASA doesn't produce anything—only paper research
- There is no upward mobility, the work isn't exciting (testosterone factor—planes not fast enough, or big enough), and uncertainty in job security—even engineers are getting smarter about how to get ahead.

- NASA Aeronautics is known in the aeronautical engineering field as the poor cousin to the space program.
- Faculty advises students to go to the private sector over the government.

NASA Aeronautics has been unresponsive to this trend of not attracting quality people: it hasn't reformed itself, because the civil service is its silent killer.

- JPL(Jet Propulsion Lab)—not civil service, but part of NASA—run by CALSTART, so good place to be.

There is a "cult of personality" problem at NASA Aeronautics. NASA Aeronautics has no value function, it doesn't know what to do to be well respected. So it benchmarks itself against person up the chain of command. Decision-making requires 30 people. There is no respect for costs at NASA Aeronautics, no cost benefit analysis is conducted. There is a sense of hopelessness because even if it puts together a great proposal it gets killed in Congress. [editorial comment: interesting perspective considering said that NASA Aeronautics is getting a lot of support from Congress these days]

What does NASA Aeronautics have to offer? (given the bleak picture he painted)

- useful function: NASA Aeronautics runs the wind tunnels
- it funds next level projects—funding source
- it keeps institutions and industrial R&D going. An estimated 15% (he speculated on this number but tried to justify how he reached it) of institutional budgets are funded by NASA—but that money is spent on funding NASA folks to be bodies at the universities—so the reality is that NASA Aeronautics only effectively contributes 5% to institutional research programs.
- NASA's budget roughly broken down:
    - internal
    - external—big projects
    - fundamental R&D—small fraction.
- NASA Aeronautics could cut its workforce and send more money out; it could look ahead; and it could keep up unique training centers.
- Chronic problem: the mission to make airplanes better in two years not ten years, and it has not credibility for 10 year technology

No national imperative for NASA Aeronautics.

By 1996, things had changed a lot. Downsizing, especially the military side had a profound impact on the aeronautics industry and reshaped NASA's mission. In the civil sector, the competition from Airbus significantly reshaped the structure of manufacturing in the U.S. Boeing has become quite strong since 1980. McDonnell Douglas, on the other hand, has been weakened. We now have the new phenomenon of offsets. Offsets are compromises Boeing makes to capture foreign markets. The impact on second and third tier manufactures of aeronautics products is beginning to have a major negative impact.

The classical definition of aeronautics is changing. Today air traffic control, entertainment systems, and ground based systems must be added to the traditional definition.

There are now vastly increased cost pressures. Airlines are demanding not only that operations costs be reduced, but now are placing major demands on manufacturers that they lower acquisition costs. Aviation is becoming a commodity. The military market is nearly dried up.

Our customer base has shifted from the military to the commercial components, of which Boeing is dominant. Our civil customers want shorter design cycles. We will have to focus on creating

models which reduce the need for interim testing. If we can model more accurately, there will be less testing. This will save money and time.

Today, there are a lot fewer companies, mainly because of mergers among all the old companies. The cold war is gone, and now economic competitiveness is the key. For example, in 1980, Airbus was just getting started, and now they're a major player.
Military challenges today aren't as compelling - it's more confusing today because we don't really know what the military challenges are any more.
The industry in 1996 is also characterized by declining expenditures for federal programs for both civilian and military applications.
Europeans have new wind tunnels that could enable them to further improve their competitiveness. The US tried to keep up in this areas but couldn't.
NASA Aeronautics' fundamental mission hasn't changed, however - it's still to develop technology for industry to use, and to provide the national expertise (people, labs, research facilities, etc.) to support technology development and to promote that expertise to industry. Basically, the mission is the same as it was in 1970 - "to study the problems of flight and to solve them."

Demographics are also serving as key drivers to technology - where people fly and what kind of people fly. For example, the anticipation of increased travel to the Pacific Rim is driving the necessity for longer range or faster aircraft, mainly because people just don't like long flight times. This is a key demographic driver behind development of high speed civil transport. Demographics are important because it forces you to demonstrate the economics of a technology before you spend a lot of money developing it.

There are major changes in the airlines' way of training and procedures resulting in human factor resource management. An increased emphasis on human centered automation because the automation is not technology driven but system oriented.

NASA is looked to as the world class center of human factors research in aviation: cockpit; training ATC workstation design, personnel beyond pilots; all the way to training of maintenance and cabin crew.

Human factor research: is the development of scientifically derived principles of how people work and applying to system operations.

In 1980 there were more separate companies; there have been lots of acquisitions since then. The mergers and acquisitions frenzy is what started the massive subcontracts that exist today.

Aeronautics is a very competitive field. The US had 90% of the market share but it is currently more like 50 %. The Government should be doing basic research not applied research. Aeronautics is in a gray area and it is hard to tell what is basic research. The large wind tunnel proposal is a good example. Applied research is viewed as corporate welfare. Industry should be doing applied research. Another example is the high speed research program. While this is appropriately basic research it is perhaps too soon for industry. On the other hand Airbus is the major competitor and it is largely government funded.

One of the main influences in the world then that drove the mission was the growth in air travel. However, then the issue of how to handle the increased traffic flow arose. In addition, making air travel more cost efficient needed to be explored.

The Aeronautics division has a much longer history than the Space division. An analogy would be to compare Europe's history to that of the U.S. Aeronautics' history goes back to the old NACA. In the beginning, there was a great deal of progress because it was the first time to do

tests on everything, develop new things, and pursue "pure" research. Now "folks" in base technology bemoan the good old days of pure research. Today they must conduct research on nationally relevant issues and applicable technologies.

Space is trying to be relevant and direct research on technologies in focused programs.

One focus program is high speed research. Within the base technologies there are milestones that are driven by the industry. The goals set are real and applicable.

The base technology research is considered research into technology ideas where focus programs focus on transitioning technology into applications.

Noise, fuel, and emissions were still very important.

In the 1980s, the domestic market was the driver for industry. Now the foreign market is a driver. We have shifted from a national focus to an international focus.

Noise levels may keep planes from landing in 2000 in some nations.

The analogy of old cars and new cars is a useful one. U.S. dominated the market and then the Japanese developed newer, smaller, cheaper, more fuel efficient cars and came to dominate the market. Now the U.S. has become more competitive. There is a similar threat to the Aeronautics industry with the Japanese or Europeans developing better technologies and growing more dominant in the market.

Our industries are not as dynamic as foreign industry. This is because our industry is not as forward-looking as those in other cultures.

In the 1980s there was a lot of emphasis on technology that could be added to an airplane. Technology sold planes. Today technology is less important. What sells a plane is initial acquisition cost and life cycle costs. Today environmental issues play a larger role in research.
Noise is clearly having a major influence in shaping the market. The basic political question which is shaping research is: “When is an aircraft too noisy? When you can see it.”

NASA research may have limited value for industry. This is because industry is very conservative. Advancement in technological capacity in civil transport is very evolutionary. Industry will take few risks. You cannot expect civil industry to be out there bouncing against the edges like the Air Force used to. Similarly, I do not think NASA can expect industry to be excited about its research unless that research involves some gradual improvement. Some people argue that the Boeing 747 was a risky strategy. Perhaps it was in a marketing sense. However, from a technological point of view the 747 was a military aircraft. It emerged in the civil sector when it was rejected as a military transport.

A lot of new foreign competition is in the market now that was not there in the 1980s.
There is also a significant use of computer analysis for design and testing that was not present in the 1980s.

Today, there are a lot fewer companies, mainly because of mergers among all the old companies.
The cold war is gone, and now economic competitiveness is the key. For example, in 1980, Airbus was just getting started, and now they’re a major player.
Military challenges today aren’t as compelling - its more confusing today because we don’t really know what the military challenges are any more.
The industry in 1996 is also characterized by declining expenditures for federal programs for both civilian and military applications.

Europeans have new wind tunnels that could enable them to further improve their competitiveness. The US tried to keep up in this area but couldn't.
NASA Aeronautics' fundamental mission hasn't changed, however - it's still to develop technology for industry to use, and to provide the national expertise (people, labs, research facilities, etc.) to support technology development and to promote that expertise to industry. Basically, the mission is the same as it was in 1970 - "to study the problems of flight and to solve them."

A Soviet threat no longer exits. As such, we have seen a shift in criteria - from performance to affordability (in terms of acquisition and life cycle of the product) - in the military, industrial and commercial arena. In addition, environmental issues (noise pollution, emission control etc.) have also grown in significance. The military arena, for the first time, is integrating environmental concerns into the planning process. Safety issues is another concern, particularly in the commercial arena. To sum up, affordability, environment and safety are the main drivers of the industry today.

Today the industry is under great duress. Military cutbacks have had a great impact. Very few new programs are underway and there are few opportunities for development. There are also few spin-offs.
Commercial aeronautics is a cut-throat business with a subsonics emphasis. It has been stated that U.S. aeronautics is in the commodity market. The deregulation of the industry had a major impact.
Firms are downsizing. This trend means mortgaging the future for the current balance sheet. Firms are cutting staffs and R&D expenditures. In some ways it is "dumbsizing" the industry. This provides opportunities for NASA. Earlier NASA gave money to the firms and then let them alone. Now the industry must depend on NASA for high risk technology development, trained personnel, facilities, and intellectual capital. This is a good position to be in, but it is challenging.

The Europeans have emerged as true aeronautics competitors. Japan is now strong in components and some technologies. The Chinese market has emerged at the same time that the potential for affinity with the Russians seems in the US interest (deep and broad relationship seems possible with the end of the cold war). GPS is a crucial new technology.

The European factor and the availability of low cost labor in SE Asia has led to the internationalization of aircraft manufacturing regarding parts, components, and service. Some technology issues are having a huge impact, esp. in materials. We are at the nascent stage of a revolution in materials technology for very sophisticated uses (designer materials) and reparability.

Currently we are using much older aircraft and engines and there are more risks in maintenance practices. A very different financing paradigm has emerged for the airlines.

In 1996 aeronautics has a more critical role in the U.S. economy than in 1980. Today we have a $176 billion trade deficit. Aeronautics is an industry that contributes heavily to the trade balance.

If the U.S. pursues High Speed Civil Transport, the U.S. can recapture it's market dominance. We can expect to capture 80 percent of the international market. If we do not build HSCT in this country and Europe does, then Europe will capture 50 percent of the air transport market. This would be a $200 billion swing from one scenario to the other. The U.S. has to solve its trade balance problem. Aeronautics exports is a major instrument. There is a trade mandate for the U.S. to insure high technology jobs and growth in the aeronautics business.

Today - very cost conscious in manufacturing and initial cost
Not technology for efficiency improvements due to lower cost of fuel today
Export industry resistance to technology improvements
Commodity pricing is dominant - all aircraft fly at same speed
responded to Airbus challenges (composites, etc.)
Military wants more advanced technology (stealth, UAV, etc.)
GA resurgence due to tort reform

- More customer driven, aeronautics funding very fragile - "Corporate welfare" issues as perceived by much of Congress - less in-house work being done by NASA

In 1996, however, we find we are in the middle of a big change. The Cold War is over and there is global competition for large transport aircraft. The NASA focus on priorities, cost, economics, customers Who uses, For what). On the subsonic side we are there on range, alt , Mach #. The relationship with DOD has changed. NASA is more concentrated on civil than military. There are many financial constraints i.e. There are too many old wind tunnels tween DOD and NASA.

Commercial aviation propulsion was viewed as a sunset industry in the 1980s.. Over the years NASA has proven that there is a role propulsion technology—by improving it.

Airframe Co.s McDonnell-Douglas, Boeing, Northrop
Engine Co.s - Pratt & Whitney , GE
Avionics Co.s - Suppliers
Airlines
National Airspace System - FAA
A Secondary level includes:
Planners - Travel
Economists

We have solved a lot of the aeronautics issues confronting the industry, there are less discoveries that need to be made. However, propulsion could still have some significant technical discoveries.
Aircraft have become more efficient, there are now fewer crew members and are more fuel efficient. The aircraft have more human factors issues today and NASA should be exploring the solutions to these human factors issues.

A large change happened to the GA industry in 1992 when Admistrator Goldin met with GA industry leaders and they expressed a desire to have technology transfer from NASA. Since then there has been three main programs to help support general aviation: Advance General Aviation Technical Experiment (AGATE), General Aviation Propulsion (GAP), and the SBIR/STTR programs. SAMA, along with NASA is now concentrating on developing an aircraft that will be the equivalent to a long range car. This aircraft will fill the gap formed by low densensity routes where commuter aircraft are not currently used. A mission range of 150 to 1,000 miles. The industry is a few years away from fielding a new plane. The AGATE consortia has planned to have a 1998 launch date for there first generation of aircraft, with the next generation following a few years later.

Industry and Government (NASA) because of limited resources have shrunk in size and span of control, responsibilities and research.

Alaska & Southwest went to HUDs because of the military influence. Synthetic vision and IR military research by NASA has benefited the commercial. Integration and Implementation of

technology has been a major problem for FAA. NASA should be implementer - more NASA efforts on "applied technology" not just R&D.

- NASA gets more R&D funds than the FAA which causes tension between agencies. CTAS is a good example where NASA R&D benefited FAA (but which FAA is reluctant to use) because of rice bowl mentality.

- Human factor is an area where NASA has the expertise which FAA doesn't use enough. FAA has their own ineffective HFE.

- It has become difficult to run cooperative programs particularly between government agencies.

- Federal Advisory Committee Act has been a limiting factor.

- Wake Vortex separation - FAA is going to make decisions based on NASA modeling not a cooperative research.

- The major point is that in today's political environment, cooperative research has become very difficult.

There has been a major technical change to the industry, information systems, both electric and optical systems. These advances in information systems have created aircraft today that could not have been conceive in 1980.
Airline industry does not appear as healthy, causes could be varied: deregulation or sudden over growth of industry. The industry is now coming out of a slump and is starting to look strong.
DOD now is not doing research that can be applied to the civilian industry, example: stealth, fire control, etc...

Night and Day - downsize, fewer facilities, less $ on R&D, military is now interested in affordability not performance, dollar constraints - market now is both commercial and military.
Cost sharing is a sign of the times. Military procurement has diminished dramatically.
Downsizing sign of times.

- High quality, reliability, maintainability now more important.

- Off-the-shelf stuff is becoming more prevalent to reduce costs - companies going out of business is problem

- Schedule and cost performance is more important now.

- Overlying scenario - reduce costs.

- More technological challenges in 80s - causing an impact on getting and retaining good engineers.

- Computer Science people on the rise communications the big deal now.

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Engine Co.s - Pratt & Whitney , GE
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Economists

- Industry is more short sighted - concentrated on derivatives (737-xxx) rather than leaps ahead (new aircraft)
Need more focus on safety
Need major leaps in technology
Major issue - new ATC systems concepts
Make US industry best in world
Emphasis on safety and environmental issues
Technology still is not the issue, it is the application of that technology that is critical
Need more emphasis on human factors to improve system safety using information technology

The rotorcraft industry reduced cost of their product and has recaptured some of the fringe market.
- They have also reduced response time (sale to delivery) from approximately 5 years to 1 year.
- Subcontractors lowering costs to become more competitive.
- Rotorcraft image is still viewed as less reliable and not as safe as fixed-wing. Also, not as available when needed because of weather restrictions.

Builders have disappeared: Grumman, Fairchild, Rockwell, N. American, Dormant Columbus Division. There was a severe contraction of the industry in both manufacturing and R&D.

Coordinated R&D is a requirement of the future. NASA role - NASA developed intellectual property is open to public domain. Engine development major continuing need, includes emission, noise, energy, size of engine and materials. Engine materials development, CIS is preeminent. We succeed in application.

- 80s - airplane drove the market.
- 90s - communications bigger player but personal connections are still extremely important.

- HST is still a continuing requirement, because of this face-to face requirement.

By 1996, Airbus had one-third of the market. It exceeded its market goal by one year and has technically equaled or surpassed the U.S. product line. In fact, some of the Airbus technologies have been incorporated into U.S. aircraft by necessity.

Airbus incorporated technical leaps that it thought would make it more competitive in the future. These technologies included the NASA high technology wing, new wind tunnels, a common cockpit for all planes, and fly by wire technology. The technologies were introduced at a low risk to the European industry and can now be sold at a good price because they had government support (through low interest loans and subsidies). There is no need for R&D recoupment, so technologies are relatively inexpensive.

The big losers in this situation are Boeing and especially McDonnell Douglas.

Now there are a lot of new ideas about civil transport. The goal of HSCT is being emphasized which will have high performance, be environmentally friendly, and economical for the average flyer with no more than a 20% increase in ticket price.

The transportation market has shifted from a U.S. domestic market / U.S. to Europe focus to the Pacific Rim, which is a major market driver. This was not a factor in the 1980s.

Manufacturing and development in 1980 was U.S. based. We now must have revenue sharing partners from the beginning of development. Production and development are both more global than before. In many cases, industry cannot sell in certain markets unless they have offsets.

There are more global partnerships. 1980 was characterized by isolated firms with internal technology development geared at gaining a competitive edge. Now industry relies on others to bring technology to the table. Industry must bring financial incentives to the table rather than new technology.

GE and SNECMA developed the CFM 56 engine with a cooperative effort. Foreign governments invest in development because it will keep their people working. The CFM 56 is now a major player.

Now partners are more aggressive and want to do more of the high technology components. This is really challenging partnerships.

The bottom fell out of the market and the airlines started to lose money. The engine market fell by half due to military downsizing. In the past, commercial and military demand tended to balance one another so that the market remained stable. Now both were falling. This fall killed profits in the industry that were once devoted to internal research. Now industry must look to a new source for R&D. This moved NASA onto the critical path for money and enterprise.

- What's changed?
- Saw support contractors @ NASA centers in 1980 (a substantial work force - by 1996 this had been cutback)
- Part hasn't changed is power is at centers not HQ
- Had more "in-house" effort in 80's than now
- May be in transition WRT aviation industry
- In past engineers viewed as working for aviation industry and designers - 1st customer - aircraft industry, 2nd customer - FAA, May be changing - Open Q what is industry? (consider industry as driver)
- staff may start to see themselves as reservoir of knowledge for nation rather than as working directly for industry
- Rotary Wing industry not happened
- discussion about need for wind tunnel - no clear ROE, no break even point, compelling statement of consequence

- Less emphasis on military - more safety - pendulum in the middle now. Equal emphasis.

- Heritage Foundation - Military saved the aeronautics part of NASA. Government wanted to eliminate aeronautics research. Golden expects NASA to be closer to the industry so that "things worked on should get on airplanes not bookshelves."
- If something is important to aeronautics, then NASA should be in it.
- Industry and NASA are aligned well in today's environment. Industry now knows that NASA will be responsive to their needs.
- In the 80s industry technologists supported NASA, today, upper management supports the NASA mission.
- Civil aeronautical community's near term needs are now being worked and must continue or their will be no long term.

Desert Storm impacted commercial market. Boeing sales decreased which impacted Northrop sales. Efficiency became the mode of operation rather than performance. HCST - R&D done by industry. Once design is solidified, NASA should move forward to the next phase. Outsourcing is the way to do business now - 1 company cannot afford to do it by themselves. Business

integration has not kept pace with technical integration (technical teams integrate which management attempts to remain separate. Integrated product teams have been in use for about 5 years in the industry. Learned the concept from the automotive industry.)

Role changed over to civil side - 1 reason was that the money was there. High speed research became one of the programs, sonic booms, laminar. The scientific community become a customer - this included both government and academia.
- Unmanned Evith vehicle and space access vehicle became major projects because of the military diminishment. Langley was in charge of subsonic civil flight activities.

There has been a traumatic change in the airline industry; The weaker airlines going bankrupt and many of the remaining airlines experiencing significant losses. New start up airlines are emerging using older equipment and negotiating better labor management agreements.

Boeing is getting competition from Airbus: McDonnell-Douglas is hanging in there but is now mostly defense oriented

There is a government revolution and an industry evolution and NASA aeronautics is reawakening. Defense is much tighter with a downsizing of all aspects including air transport and bombers and fighters.

Military is dominated by Mcdonnell-Douglas and Lockheed
Lockhheed bought General Dynamics: Northrup bought Grumman
Dearth of new programs
JSM will support four services
AF, Navy, Marines, Royal Navy
There has been a lull in buying on both the commercial and military side since about 1993 but in 1996 the commercial side seems to be on the rise.
There is no new development going on; New military and civil aircraft are derivitives of current models.

Note In 94 and 95 Switzerland bought more fighters than the US did

No comparison to the 1980s—budgets are squeezed, and projects are low **Survival is the name of the game.

General aviation has gone through a near total collapse and is starting to recover thanks to tort reform. Business jets have continued to grow in numbers. Airlines are still trying to cope with deregulation.
The FAA has allowed the nations airline infrastructure to crumble and is no longer the world leader in air traffic control.

Tough times in the GA arena until 95-96 when products began to sell again. Proposed user fees may have a detrimental impact on GA. NASA funding for aeronautics not as high as it needs to be plus there isn't enough coordination between FAA and NASA. Users have had minor connection with AGATE program. Manufacturers are primarily involved. AOPA concern is that work isn't near term practical work that can benefit consumers near term.

Today the industry is weaker with more outside competition, Airbus. Industry is still conservative and is not will to bet the company on new a whole new concept so future aircraft will continue to derivatives of current models.

There are four players Boeing, Airbus and Douglas. The US airlines have felt the brunt of deregulation: the rest of the world is just starting to experience it. Some areas might never dergulate.

Searching for the bottom- "Comptollers running the world"
No long term focus, production rates dropping, deveolpment dragging, engineers being laid off. Commercial world is a little bit better.

Industry is worried about survival, trying to maintain their critical design teams, work is being passed across an industry that is too big; industry is interested in building it cheap, not sexier; there is a focus on near term return for stock holders; the major air framers have become assembly houses with much of the component work being out sourced.
The commercial segment is driving the industry; the military segment is trying to hang on but there are too few new starts and they are still recovering from the 80's where DOD forced a lot of risk taking down onto industry; today's industry is very risk adverse, there is no strong thrust for speed.

Aero contribution to the balance of payments is over $100M (Only industry with a positive balance of paymants) Helicopter sales are down. Reductions in the military are woorisome. Weare headed back to a 1939 army. the money for development is down 4 or 5 to 1. Aeronautics job market looks grim for the future

In your own words, what is the NASA Aeronautics mission in 1996?

Government / Industry partnership that is a benefit to both the traveling and non travel public.
Should be: Not buying into the corporate welfare idea, should address basic public good and needs.

NASA is not certain what their mission is, they are currently doing focused programs but some in NASA want to return to doing more basic research. DOD and the FAA have recently had there basic research budgets zeroed out.
Should be: Aeronautics should not be a part of NASA, only 5-7% of the budget is directed toward aeronautics. Government should combine the FAA, DOD and the aero part of NASA to create a new NACA to remove the redundancy currently found. This new NACA should have a full spectrum of research projects, some short, mid and long term projects. In the past NASA would start a project and hoped for technology push, today more projects are technology pull demanded for by industry.

NASA aeronautics is an out growth of the old NACA agency and still has the mentality that they are a group of old wise men doing basic research. He believes that the focused programs that NASA is currently working on are the right types of technologies to pursue.

Continue the pursuit of advanced airframes and wing design to produce the ultimate aircraft. Improvement to todays aircraft will be the combination of thousand of smaller steps and refinements.

NASA mission is to work closely with industry to create critical technologies, they have a short term view. NASA needs to develop both short and long term technologies that will supply high payoffs to industry. They need to supply a strong leadership role.

NASA currently does not have strong aeronautics leadership or vision. In the past, NACA's charter was to go out and explore new technologies to see which would work. Now NASA is

being market driven, they need to be the "path finders" for industry, and get involved in the total process of manufacturing.
NASA has a large responsibility to do wind tunnel testing for industry since in the 90's they sold off many of their private tunnels.
NASA still has a need for supercomputers but industry is moving away from super computer time by using work station clusters.
NASA should make a decision if they are going to pursue a HSCT or not.
Should be: NASA needs to be redesigned, they should not be involved in research that industry should be doing. They should lead industry, not follow.

Today's mission is more complicated for NASA to understand its role because the customer is more complex. When dealing with the military, it was easy to identify their goals, no so with commercial.

NASA is now much more customer oriented, they are trying to bring both industry and other government agencies on board. Today's NASA is marred with constant change in research goal as political parties change power positions, Democrats lean more towards corporate welfare (short term projects to support industry) and the Republicans lean more toward long term precompetitive research.
Should be? Integration of finding solutions, long term research, discovery.

NASA is trying to conduct research that will maintain funding, its existence in aeronautics is questionable.
Research mission is to conduct short term research that can be develop in to products.
The cause of the shift to short term research is that when money is tight, long term research is the first to get cut.
Projects at the centers are not time dependent, researchers feel that what they don't finish today will be completed next week or next year. Researcher don't know how to let go of a project
Performance means little, cost means everything, NASA must learn to understand where the products the are developing are going.
NASA has too many free thinkers, no aeronautics strategic plan has been developed. There is no aeronautic leader in NASA and they are getting little support from Administrator Golden.

HSST, short haul/tilt rotor, subsonic, hypersonic research; not focus long term, focus program are the main portions of the budget. Parts of NASA are still trying to maintain long term research and technology development.
Future of NASA: Spin off of aeronautics and possibly combine with the FAA. Government must be in the technology industry. Our biggest competitor is not another manufacturer, it is another government.
Quote: "NASA is a space agency"

NASA is torn up internally between university type basic research and the focused programs. NASA should have some basic research but it should balanced with focused programs. When NASA tries to do focused programs, however, they get hit by some in congress as supplying corporate welfare. So NASA tries to hide some of there programs, both basic and focused.
Access to space is a "low ball" to the aeronautics industry because when the space budget came under constraints they created this air breathing access to space program. They are taking money from aeronautics program to pay for space access. This program is not in the definitions of the aero industry. Plus, where is the logic behind pursuing air breathing access to space so closely behind a major award to Lockheed for the development of the X-33 single stage to orbit program. This would seem to be making the X-33 obsolete very soon after development. NASA should not stop doing hypersonic research, but the space side of NASA should pay for it.

Comment: Fundamental comes from the military funded research; NASA provides applied research and technical validation..

NASA's mission has changed to accommodate the new emphasis on civil aviation. The HSCT and AST programs have emerged as important foci. We are attempting to change the paradigm to producing a product, not just doing basic research. While NASA is still pursuing some basic research, we are now spending more money for focused, applied based research.

The mission needs to be focused on more balanced research.

Updated version of 1980
- Venture development for future - far ahead
- Computation development

World aircraft fleet management
- GPS will tie it together
- i.e. flight recorder should be data linked to ground, important crash info

The 1996 mission is to maintain the balance between support for military and civil aeronautics needs. Further, these two factors have to be balanced across national goals to show that the NASA role integrates with the FAA and other government bureaucracies.

We should put another one-third of a century into supersonics. It is critical that we make the correct decision about supersonics and we must develop the data and research to determine what that decision should be. It is also critical that we decide whether or not we can make it work so that it is environmentally safe and economically feasible before we commit entirely to fielding the aircraft. We must be right about this decision. If we state that it cannot be done and another entity does it, we lose that market and are playing catch-up again. If we state that it can be done and fail, we have wasted incredible energy and resources on the matter only to have it fail. The implications of either incorrect scenario would be severely detrimental to the industry.

The Concorde was not economical enough to threaten our industry.

The "big swinger" for the industry is supersonics. The "little swinger" is subsonics.

Subsonics are driven by a lot of decisions. There are many things to balance. NASA provides technology and scientists to this arena so that industry can make decisions about what to build and whether to continue with programs.

Airbus builds good aircraft and it is less conservative than Boeing and the other U.S. actors in the industry. However, government investment in the program has helped industry to defray costs. This type of government support is a key to the success of Airbus in an industry where if you miss a little, you are no longer commercially viable.

It is unclear if the U.S. would be able to replace airplanes within the international markets if another entity took over the lead in airplane manufacture.

NASA’s mission in 1996 still is the fundamental tasks of 1980s. However, today we must be more conscious of the systems impact: global air, terminal systems, DOD systems. We must be more conscious of the systems benefit of our investments and research. Moreover, we are more involved in the hard practical research questions. In the 1980s and even earlier we were the Pump primers.

There is no mission. The nation doesn’t know what to do with NASA.

NASA's mission has changed, yet we are not sure what it is. Some think it is the focused programs. others think we should return to the original mission of basic research. Their argument is that basic research is an important role for NASA because the Air Force has abandoned basic research and so have the manufacturers.

In terms of our mission to reduce noise and emissions, it has changed. We have solved the black soot problem. Now we must focus on high altitude emissions.

Air traffic management is another important future mission. Cities are reluctant to build more runways. We will have to find ways to enhance traffic flow. Computer intelligence is the direction we are going with this research mission.

I am not convinced aeronautics should be in NASA. I think we should take all the R&D out of NASA and combine it with Air Force, FAA, and DOD aeronautics research. Create a new agency called National Aeronautics Agency.

We should work on a broad spectrum of foci. We should have a group of projects that have a high potential for pay off in five years. We should have projects with ten year potential pay off. We should have projects with twenty-five year potential payoff. Right now all the focus programs are designed for seven years and they are done. This is too soon for many of the technologies.

Today there is too much emphasis on immediate problem solving. There is not enough commitment to basic research.

NASA's mission is to support needs and requirements of the commercial aviation industry. Because industry is what drives NASA, NASA is a customer oriented organization.
NASA was at the outer frontier of aeronautics R&D , but now with cutbacks, it's hard to keep the energy up. Due to budgetary constraints, NASA has been getting more into niches. And NASA has been faced with a problem attracting the best people.

If Gore people enter the White House, a partnership and competitiveness philosophy will result which will be equated with corporate welfare , and therefore probably pummeled in the budget by the Republicans.

> There is nothing wrong with government/industry partnerships, but such a view makes planning difficult when a new administration comes in (when the new administration thinks differently, throws off all planning assumptions). If Democrats win in 1996—good for NASA

Since Goldin came into NASA, sympathy for aeronautics on the Hill has been apparent.

What if 4 or 5 TWAs at the same time?--Would have a devastating impact on the industry

The Clinton administration, and this Congress favor aeronautics. Does favoritism exists because so many Congressmen have a lot of private planes?

NASA should be doing basic research, it should be farsighted, NASA should invest in the infrastructure, and one the NASA roles should be to bring industry together. NASA needs to clarify the Aeronautics mission; Space gets perhaps too much attention and aeronautics is ignored. For instance the Wind Tunnel program needs private sector and military support in order to succeed. DOD and the industries that support it appear to have a dual military and civilian role in Aeronautics.

NASA's mission has changed due largely to the fact that the supplier and customer relationship has changed. Industry is very commodity focused. NASA, on the other hand, needs to be technologically focused. Together, we have to use our technology to attack commodity issues. Technology must be used to improve cost and performance. If we provide a service it has to be couched industry terms. However, it may not be the world influences that caused this relationship, it may just be the nature of evolution.

Looking out at Aero in NASA from a Space perspective, it will be interesting to see what the role of Aero in NASA will be ten years from now.

The mission of NASA has not changed from supporting market concerns since the 1980s. The parameters have changed because markets have changed. There will be more emphasis on general aviation (GA). GA disappeared due to liability laws and a lack of competitiveness.

When the GA industry started it was dominated by "home-built stuff." It never used new technology. It utilized technologies from other industries and worked with old technology. It never really moved out of that until recently. Now they are trying to increase investment in GA because the market is growing and new technologies can be inserted into GA products.

The mission has not changed but has shifted focus. Now the question is how long we can support GA and how much technological support does it need?

He stated that we need to determine what the product of the industry will be and whether the industry is mature. Even a mature industry can continue to develop. The airlines should experience some maturity and growth based upon customer demands for increased safety and better treatment on the airlines. People may be more willing to pay for creature comforts in the future. If this is the case, the government has little role.

It is unclear what the real goal or the hallmark of maturity will be for the airline industry.

The mission should emphasize moving the target of industry to some goal that will be critical for the future. NASA must balance investment between the current fleet and the next generation. That decision making process should focus on what we must spend on the current fleet and devote more to the future when allocating research funds.

He stated that we are not good at innovation--we are always playing catch-up. NASA needs to work on what the industry's product line will be in 2005 or 2010. New aircraft only enter the market about every 10-15 years. We need to get a jump on the next generation of aircraft.

We should develop a mission that focuses on Earth to orbit access to space. This will break down the wall between Aero and Space. NASA should emphasize the synergy between Space and Aero. Many technologies are applicable to both. NASA must think about access to space and Aero must join with Space's work on the concept. The paradigm for Aeronautics would change if it participated because its customer would change from industry to perhaps NASA and its customers.

Our mission in 1996 has become focused on the means by which we can make a commodity cheaper. We should be working on advanced technology to move beyond the present generation. But our primary focus seems to be supporting industry in its effort to make a cheaper aircraft. This is a mistake. The U.S. cannot compete in the commodity market. We can only compete in a technology arena.

The mission is focused more now on commercial applications than in the past.
It works more as a partner with industry now which was not the case in the 1980s.

The current mission was not far off from where it should be.
We are working the environmental aspects of systems.
There is a future systems emphasis with pay offs for the country.

I see NASA as a catalyst, providing advanced technology that can make all this happen By "this" he was referring to US companies having the competitive edge in safety, affordability and environmental friendliness over foreign firms.

There has been no real change in mission. "Deja vu all over again," is a good description. Questions about roles are all that have really changed.

The NASA aeronautics mission in 1996 is uncertain. Many (previously) exogenous factors are having a large impact. NASA is learning that the whole world can effect its missions.

In approximate order NASA Aero is to:

- Support advances in space transport
- Support advances in computational capability (ATC, avionics, pilot interface, etc.)
- Support US aeronautics industrial base (defined as *existing* industry)
    - threat here is that we only work on what we know
- Support new promising high risk concepts (from basic research to x-plane)
- Understand and standardize materials
- Help US balance of trade
- Help support and inform US foreign policy
- Support National security initiatives

The NASA mission should be:

- mostly the above list, but we should add
- Support emerging industries
- Do a regular audit of core competencies looking particularly for things
    - we no longer need
    - that can be outsourced
- Inventory the remain competencies for ranking and benchmarking
- A problem NASA Aero must avoid – we might be too comfortable with what we are and what we do.

The NASA mission should be to become a partner in doing risk reduction through tests of new technologies which will make U.S. industry more competitive. For example, tests of extruded materials suggest that such materials may provide structural strength and eliminate riveting. However, this is a high risk innovation which requires substantial testing.

NASA moved away from basic research.

The response to the mission for NASA in 1996 elicited the fact that the mission 10 years ago emphasized the investment in Engines and Airframe while the 1996 mission is broader and includes such things as avionics, information technology. It emphasizes the NASA expertise in

Aerodynamics,
Structures,
Digital Avionics
Propulsion
Information Technology

NASA is still doing technical enhancements for industry.

NASA needs to learn how to support this type of generation development in aircraft. Not every product can be an Appollo mission with all new technologies coming together to solve some major problem. Industry does not work that way, they do incremental steps when developping aircraft.

The mission of NASA is still to develop the long range technology base for both military and civilian aviation. In the 80's NASA worked closely with DOD to develop new technologies for the military, now this has almost ended. Today NASA works closer with the FAA to develop traffic management system, but this working arrangement is not as close as it should be.

NASA Mission. Maintaining US leadership in aviation. What it should be - more partnership with industry and academia to maintain the leadership. Need to build infrastructure with ties to industry and Gov. so that we continue to build infrastructure.

Areas where NASA should concentrate:
Propulsion - aerodynamics, structures, flight controls, safety, - world wants speed but technological problems exist which NASA should work. Sonic booms, ozone layer (Overcame inhibitors that allow entry into the markets.)
Future emphasis on safety other than equipment and human factors.
Broad based NASA research should be both military and civil.

The response to the mission for NASA in 1996 elicited the fact that the mission 10 years ago emphasized the investment in Engines and Airframe while the 1996 mission is broader and includes such things as avionics, information technology. It emphasizes the NASA expertise in
Aerodynamics,
Structures,
Digital Avionics
Propulsion
Information Technology

Perceived NASA Mission. Not sure.

Change in mission between 1980 and 1996:
NASA's announced mission: Clinton's R&D goals –he's not walking the talk regarding aeronautics. Aeronautics are on a tight reign regarding investment, especially when military aeronautical funding is decreasing.

NASA and military developments are in sync even though military expenditures are going down, because NASA's budget is also going down. This means that the national technological base is decreasing as a whole because there has been no conversion of funds from the military cuts to the civilian/commercial side.

The industry needs development of next generation facilities because nothing in the US compares to the Europeans. The Europeans are building the necessary facilities and infrastructure which gives them world class testing facilities for subsonic planes, unlike the US. The US has backed away from updating facilities. We need better accuracy and productivity. Our infrastructure dates back to post WWII. **Golden decided to shut down the wind tunnel project despite Congressional approval. US infrastructure is not equipped for rapid speed development.
McD and Boeing are both using European wind tunnels—they are using overseas wind tunnels because of the shortcomings in the US.
This is why McD and Boeing are willing to make significant contributions to the building of wind tunnels even though it really should be a joint industry/NASA project.

NASA Mission - To promote the advancement of aeronautics in US and development.
- Should be -needs to be more generic other than engines, airframe, aerodynamics.
- More interface between FAA, NASA, DOT in regard to where we are going in aeronautics.
Major drawbacks to advancing the aviation system. Sharing military and civil advancements is a future need.

- NASA should be involved with:
engines
software safety
materials
connectors (unreliable, costly) if we continue with wires.
rain and ice repellent - deicers not environmentally safe.
interaction with airplane and pilot (who does what) real safety issue control system designers - major concern.
- Market place want reliability -industry has stagnated. Reliability is not improving. Safety is the major issue.
- Industry needs to follow the consumers needs.

Environmental concerns have increased in importance. Performance is no longer the primary driver.

Industry cannot sell aircraft for the same old prices. Affordability in purchase and operations cost has become a major element. Package deals are now the norm where maintenance and financing may be sold with the aircraft.

Manufacturing efficiency is now more important. Parts must be made correctly the first time. They must be designed for easy manufacture and maintenance.

NASA has opportunity to become center/long term S&T given up in private sector, aircraft transport-only ones who can afford to do long term work is Boeing - not sure how long will continue
- Derivatives rather than new designs now rule
- Different FAR guidelines in 50s/60s than 80s/90s allowed exploration of more alternatives
- Can't blame on budget (contractor $ not changed that dramatically)
- Nation become more cynical, more near term, less willing to invest long term for technology and families.
Why? - process's developed in private sector and within government
70s - Congress assert role, exert influence over what check being written for - explosion of staffers on hill, more oversight, less doers
- process to put together, get budget passed.
- people want to predict total S&T success
- Another change - things have become more centralized
- Congress became more powerful
- industry needed to pay homage - become more centralized - no longer able to take risks at lab and company level.
If decentralize and put back to staff, still doesn't help b/c still need to package and put thru Congress.

NASA Mission - Make airplanes safer and more efficient. Focused planning versus General R&D. Work with industry to do above.
- Design and implement new systems. Continue general Research even though big metal people aren't necessarily asking for it.
- Software changes and other internal changes are expected in the future.
- ** Should NASA Mission be different - Less emphasis on focused programs.

to near term focused.
eliminate center redundancies and standardize procedures (payroll, admin, etc.)
not micro managing Dryden's budget
NASA should be doing critical high pay off technology - open system architectures - alternative back-up control systems (other than mechanical) propulsion still needs to be worked out. More unmanned flights through autonomous computer technology.
- Autonomous systems provide more R&D flexibility.
- Oil is a limited/expensive resource - need to research this.
- More televideo conferencing - less flying

NASA Mission - protect national facilities. wind tunnel, crash facilities, etc. and Protect National tools - emissions, noise.
Near term stuff - should do flight research - composite materials, high lift, laminar flow, other applied research which would benefit US
Far term stuff - aerodynamic efficiency includes near term stuff - plus advanced technology projects.

mission - high speed research and subsonic civil research, access to space program.
- What should it be - more x plane activities, new airplane research (hypersonics) high speed civil research. X-33 and X-34 research should be expanded.

- Why is it such - exploratory research on smaller size programs are being emphasized. Shorter term programs with more near term benefits to the user should be emphasized.
- NASA needs to be more involved I n keeping the US aeronautical industry more competitive. Airline industry globalization complicates the NASA mission because NASA research may now be aiding the foreign markets.
- Military is going to continue to lead in technology advancements.

NASA aeronautics is more focused; seems to be a resurgance of aeronautics and basic research
NASP was a bureaucratic disaster

Accomplishments changed—became more focused on the commercial side—reacting to pressures to support commercial industries to the extreme. Under Congressional pressure, and shrinking military budgets, its struggling to show relevance in aeronautics. **Airbus.

NASA aeronautical struggling to justify itself—leadership at NASA.

Congressional support always strong for NASA Aeronautics (??)

The A is back in NASA. The agency has started to do research that will help the GA market; example: AGATE and GAP. Industry now has more input and a role in NASA's research. However, there are still a lot of projects that are engineers dreams, not market pull; example: HST and the tilt rotor.

NASA aeronautics is in a decline due to budget pressures, DOD is still there but is not as strong. The federal government is in a reduced mode, currently pushing responsibilities out to industry to develop new products.

Maintain US preeminence

Refocused
- Competitiveness
- Product oriented
- More business discipline

Less fundamental research

The are looking for a role, NASA is a secondary player that has very little impact on military aviation.

No long term programs, several short term, nothing coming behind to replace these programs. No funding commitment. No feeling for long term research. No interest on civil side to support space program. If we are going to have a space program it is going to be funded by military or NASA, its better if it is NASA.
A lot of military funding coming to an end for NASA.

NASA mission is unchanged but the interpretation of the mission has. Safety is consuming the budget. People do not understand that research is risky and failures will happen. (Both aero and astro) Comment:Goldin is not the problem

What would you list as the critical technologies? Why?

Light weight high endurance/temperature materials
Noise reduction for engine/airframe
Emissions reduction
Information technologies; air transportation management, free flight
Safety related technologies: minimizing hardware/software failures, reducing human/machine failures.
Why: Capacity issues: environmental, something might constrain the market
Process Technology: the ability to get things to market quicker/cheaper, lower unit cost.

Shorten Design cycle time: today aircraft must be built cheaper and quicker with more use of wind tunnels and computation models. Better models are needed to predict the success of an airframe earlier to reduce airframe manufactures risk.
Air Traffic Management: Cities are not going to build more and more airports, so if capacity is going to increase the system has to be improved; satellite navigation and computer based scheduling will same money for airlines.

Airport Capacity: This problem is technically easy to solve but is politically impossible. There are two solutions: build friendly aircraft such as tilt rotor or very quiet jets or build large aircraft that could fit into todays infrastructure and lower the total number of aircraft flying.

Technologies that will lead to high payoffs.
In Japan they have technology fusion, one industry can use anothers break through and get it to market quickly. We must develop the same strategy.
Simplified structures, example: bearingless main rotor
More durable longer lasting materials possible made from composites.
Noise reduction.
Use airspace more efficiently.
Use GPS technologies more.
NASA facilities are a critical technology to US industry.

HSST
New concepts in simpler systems.
High lift aerodynamics.
Combine the different disciplines of aircraft manufacturing to make the production of new aircraft more efficient.

Capabilities that allow industry to adapt quickly to the market place.
Information technologies.

Structures and material development; reduce manufacturing and maintenance cost of aircraft; being able to get new aircraft to market quickly; develop performance (wind tunnels) and production

Speed / Systems: metric of both
Transportation Industry must reduce travel delay time, address system issues, looking for more efficient propulsion systems and aerodynamics, and finally improved safety. The industry also needs an increase in capacity such as a High Speed Supersonic Transport, but must also address the environmental and engine noise issues associated with an HSST.
Mission to Planet Earth: very high flying autonomous aircraft.
Hypersonics: There will be a closure of the gab between air and space in the near future with a lot of interest now being expressed in an air breathing space vehicle.
AGATE: new cheaper avionics and propulsion for GA.

Reduce design cycle time, reduce risk, get products much quicker.
Develop CFD model to capture a lot but not all of the physics of a problem.

Information systems, design and design technology (begin to design the entire aircraft, not just part by part). Current techniques are slow and there must be a reduction of the cost of design.

Safety, there are not major technologies out there undiscovered like the sweep wing or jet engine.
Air Traffic Management, Free Flight, traffic delays
Environmental issues.
HSCT- without this technology Boeing could lose a major share of the world market, with it they could dominate the market.
There is no one big driver but a lot of things need to come together for the future.
Composites are not here yet in the US.(Europe has jump through flying the ATR-90)
Weather causes 65% of traffic delays

We need new disciplines in aeronautics. We need a new integrated approach to aerodynamics, structures technologies, and flight control. Resolving any one of these issues has implications for the others. In fact, solving problems in one may actually complicate the others. In NASA the three are too separated. This is counterproductive. We need a new, "cognitive engineering" approach that incorporates many different disciplines.

Hybrid control is a theory that should be emphasized for the air traffic management systems of the future.

Integration of human and automated systems will be crucial. It must focus on the benefits of each rather than what is easy to accomplish. Such integration should be based on what the human does well and what the computer does well.

Information technologies, not technology development but innovative applications of information sciences, will be critical.

Simulation technology will play an increasing and important role in design, accident investigation, and other aspects of the industry.

Multi use airframe development
    Mid range commercial jets
Non commercial aircraft

Multi use FAA certification
Commercial Aircraft between DC9 and turbo prop
Gap needs to be filled
Potential huge audience demand
Global Wind measurement
Master routers
Flight optimization
Environment impact of subsonic fleet
40% reduction in co2 emissions

A comprehensive physical understanding of environmentally significant aspects of aeropropulsion is important. NASA stands alone here in playing a role to pursue this goal. This is very important because no one else can or would take on that role.

Other goals are performance efficiency, performability, and survivability.

An additional, but smaller, part that is unique to NASA is pursuing the safety and security aspects of commercial travel. This is particularly true in the area of icing which has been a niche for NASA since WWII.

A militarily unique role for NASA is the ability and desire to focus on much faster out-time frame than most of DOD can afford to do. NASA can work with industry or government as a sponsor to pursue topics of interest to the entire industry. This allows firms and DOD to pursue future studies and focus blame on NASA. (In other words, when industry or DOD see the need to pursue long-term research on an issue they can team with NASA. This allows industry and DOD the luxury of distancing themselves from such research if it is politically or publicly unpopular at any time by pointing the finger at NASA.) This allows the industry to keep sight of the future in spite of fluctuating funding and economic prosperity levels.

There is a corporate welfare aspect to NASA. Firms feel that taxes should somehow feed back into the industry and help national welfare through this support. Boeing, for instance, never has a problem asking the government for money and then telling it to get out of the way.

The public and government question why they should commit funds to the industry when there are "a bunch" of dollar rich aviation firms out there. Why devote funds to a cash rich industry? Industry wants the tax dollars and technological input without any additional interference.

The following are the critical technologies NASA is interested in promoting today: (1) Applications of information systems technologies (preliminary design, concept certifications); (2) Propulsion (engine efficiency, noise reduction, emissions reduction); and (3) technologies related to increased number of passengers (we do not have sufficient airports, we must expand capacity to handle more people). This last technology group is a system issue that translates into a number of technology requirements. For example, there is a major need for improved communications between aircraft and the airport. We need to consider means of better exploiting free flight, improved early warning, sensors to avoid bad weather, and deicing technologies.

Those that NASA has capability are aerospace, civil, military aeronautical technology, including air traffic control and safety. Potential for dramatic restructuring of civil aviation market place due to common technologies. Potential for both large losses and growth. In civil, air freight growth. In military, radical new aircraft design such as uninhabited aircraft, low profile aircraft [?], and high observance aircraft. The NASA report “New World Vistas” summarizes these opportunities.

The critical technologies are mainly civil-oriented and include aerodynamics, propulsion technologies, and structures. Particular programs include high speed civil transport, air breathing access to space, and new generation subsonic aircraft. Basically, technology is being driven in the direction of safer and more efficient aircraft. We're likely to see subtle changes in materials, aerodynamics, and propulsion.

Noise abatement—with higher speed engines need to worry about noise. Because there are more megacities around the world, and an increasing concern for standard of living and environment, have to worry about noise unless plan to build airports out in the middle of the nowhere.
Don't underestimate environmentalism—it hasn't gone away—its always hovering in the background—environmental shock/impact from noise and exhaust.
More fuel efficient engines—structures, lighter weight materials—its a long-term issue

**Brain Research
computational technologies—has a great impact on aviation systems.

Materials: high temperature materials which influences engine designs; airframe components also need to be high temperature capable;
Structures: atmosphere phases for launch vehicles—structures
Propulsion: specific fuel consumption—low
Application of micro-electronics (feedback control systems)—SMART materials and structures; electronics in design—computers are important as costs become more important. **Its hard to tell how much a plane is going to cost (production and operation costs). Because can't rely on experience, because no experience in the alternatives, so have to go to basics.

Materials and High Speed research even though it appears a little early for industry. NASA needs to be more removed from industry vision wise but be attuned as to where industry is going.

The following comment was offered. The ace side of NASA recently awarded the X-33 contract. The choices varied from very conservative, to mildly risky, to very radical design. The radical, visionary design was chosen. OMB liked that: this is the role for government research.

OMB also likes milestones and metrics for measuring basic research. They think the high speed research program has a good set of metrics. They also like the way the DoE measures the operation of the research facilities; changing models out, turn around of experiments, etc.

The critical technologies are the high pay off technologies. High pay off technologies are those that (1) drive down acquisition costs; (2) improve performance without raising expenses; (3) consider the safety factor; (4) account for capacity; and (5) effectively handle the increase in traffic landing slots.

The critical technologies NASA is working on are the following:
In the military area we are assessing automated functions; ways of reducing the role of the man in the plane. We are examining unmanned technologies such as sensors. Once you get the man out of the airplane the possibilities for improving performance will expand. In the civil sector we are looking into high lift dynamics, noise reduction technologies, and integration of propulsion systems with air frame.

While HSCT is a high priority focused technology I am not certain this mission can be accomplished.

I am not sure I can answer this question. I cannot think of anything that is a high pay off that needs to get worked. HSCT does not have a big pay off and will not, however, it is currently NASA's shining star.

The critical technologies are mainly civil-oriented and include aerodynamics, propulsion technologies, and structures. Particular programs include high speed civil transport, air breathing access to space, and new generation subsonic aircraft. Basically, technology is being driven in the direction of safer and more efficient aircraft. We're likely to see subtle changes in materials, aerodynamics, and propulsion.
Demographics are also serving as key drivers to technology - where people fly and what kind of people fly. For example, the anticipation of increased travel to the pacific rim is driving the necessity for longer range or faster aircraft, mainly because people just don't like long flight times. This is a key demographic driver behind development of high speed civil transport. Demographics are important because it forces you to demonstrate the economics of a technology before you spend a lot of money developing it.

Performance is very important We need the necessary technological breakthrough in fuel consumption, better jet streams(?). Materials continue to play an important role in this industry and affordability is vital if we are to use them. On the computational side i.e. modeling air dynamics, both externally and internally, NASA plays a big role in developing (computational) tools. Experimental data is critical and NASA can provide us this information. P&W relies very heavily on data in the high speed region and the tunnels are very limited in this area.. Today the "national wind tunnel issue" is being heavily debated,

From a propulsion perspective, environmental compatibility and economic viability.
Technologies must comply to today's and tomorrow's rules. Technologies for the environment give us a comparative advantage over others.
We must balance economic concerns with technology. Components should not be developed if they will not be cost-effective.
Safety is important, especially aircraft deicing research, wind sheer, and heavy rains. We need to have technology to contribute to these efforts.
Human factors are also important such as better awareness in the cockpit and earlier views of impending troubles.
For the military it is performance and survivability. Industry must provide protection of the investment as well as high technology.

Propulsion
fuels
Materials
Alternative configuration (esp. for high speed)
"Drive" capability rather than "pilot"
autonomous controls
Operations – vehicle mix
ATC / GPS
away from positive control in most areas
VERY IMPORTANT – we must start working on a transitions plan
from the legacy system
for personnel
for planes
Air - Space interface and the trade-offs
Transport modes – few big, many small, mixed ?
Ground facility use
Ground transport - air trade-offs

I really feel qualified to discuss material technologies among the technologies NASA should promote. Advance materials is an enabling technology. There is rapid and exciting change in this field. We can create and design materials on a computer. We can model these materials.

Industry has no such capabilities. Moreover, we can cooperate with other disciplines. The aerospace industries are handicapped in terms of multi-discipline approaches to new materials. For example, Boeing engineers do not communicate with pharmaceutical scientists.

We recently worked with the automotive industry help them with new materials. But we also learned from the automotive industry how to make things faster. By working with experts outside the aeronautics field we learned new manufacturing technologies and paradigms that we can spin in to aerospace.

The critical technologies are :

- Safety
- Environmentally Friendly
- Competitive
- Noise
- Compatibility
- Engine emissions
- Satellite based ATM system

Propulsion and space—need marriage of the two technologies to form aerospace technology. To lower cost combine rocket system and air breathing propulsion within the same mechanical frame. The time frame is based on cost. The military application from this aerospace technology could be a small missile. There's room for commercial ventures ??
What to do in the next 20-25 years? Need to think revolutionary not evolutionary [He really didn't care to elaborate on what revolutionary technology would be, even when probed]. Ex: engines for commercial plane: subsonics doing well so a follow on to the Concorde, maybe need to look at hypersonic—75-100 passengers and subsonics—larger aircraft, around 1000 people. Although there isn't a big payoff in large planes.
Fundamental research is required in some areas—technology packages.

Thermodynamics

- Materials-Structures
- Cockpit Technology
- Human Factors
- Propulsion
- Instrumentation and Test
- Information Technology
  - High Performance Computers
  - Software
  - Strategy Tools
- Flight Research
- Avionics Functionality - Not Imbedded Design

What makes these critical is :

- Superior performance
  - Affordability
  - Efficiency
  - Survivability
- Operations
  - Safety *US+World
  - Capacity *China
- Environment
  - Noise
  - Emissions

Electronic systems - flight controls, synthetic vision, automation (cockpit)
Materials and structure development (composite, engines)
Health monitoring equipment
No major improvements in aerodynamics as compared to structures and materials

The environment is the key factor in todays industry. Noise and engine emissions are going to become the number one factors to the industry. We will solve the ATC, facilities, airports, safety, and terrorism issues in the near future.

Computational displays, GPS, telecommunications, moving maps, data link providing weather and traffic information. The FAA is too slow in approving new technologies and the commercial industry now has much higher standards then the FAA require for general aviation instrumentation.
Propulsion is on the verge of a big advancement, with NASA supporting engine development for GA with the GAP program. Currently, an engine based on 1940's technology is 1/2 the cost of an aircraft, this amount must be reduced with an advancement in engine technology.
Flying must be made easier. Right now 33% of the population say they would like to learn how to fly if it was made easier and still maintained a high level of safety, only 0.1% actually do know how to fly now. Of this 33% about 10% of the population would follow through, still a very large growth from 0.1%.

New Materials = critical technology. Because of cost and safety.

Human/Machine interaction, this should be explored by both NASA and the FAA.
High speed aircraft, both super and hypersonic.
Health monitoring systems for aircraft, anomalies in aircraft structures and engines could be recognized and repaired before a major failure occurs.

What are the critical technologies that NASA is the pioneer and leader of? elicited the following:
Aerodynamics
Thermodynamics
Materials-Structures
Cockpit Technology
Human Factors
Propulsion
Instrumentation and Test
Information Technology
High Performance Computers
Software
Strategy Tools
Flight Research
Avionics Functionality - Not Imbedded Design

What makes these critical is :
Superior performance
Affordability
Efficiency
Survivability
Operations
Safety *US+World
Capacity *China
Environment
Noise
Emissions

Information technology - safety issues using new IT
HST
AGATE products
All based on IT as the glue

Critical Technologies. Improved engines, use of composites and automated fuselage building were mentioned.
Why?
- Need more cost efficient engines.
- Need ability of 1 engine operation.
- Need reduced rotor speeds for noise abatement.
- Existing engines limit vehicle size, capacity, and speed.
- Vehicle fabrication is still described as garage style building.

technology base for tilt rotor—V-22—it took 40 years of technology development to get to the point we're at today.
critical air flow technology—Dick Whitcomb at Langley
NASA is a heavy contributor to composite materials to reduce current weight of commercial and military aircraft, which could move into wing design and fuselage.
Technical promise underestimated the reduction in costs to compete with metals.

For propulsion these are:

- Low emissions technology
- Low noise technology
- High performance/ efficiency
- New materials that are light weight, strong, and affordable (including composites, CMSs, and ceramics)

Industry worries more now about processing technologies so that they are done correctly the first time.

Development time is shrinking to about half the time and half the cost of previous time schedules.

HSCT engines have the noise, emissions, and inlet challenges. How do you solve the problems efficiently while controlling for weight and affordability? The impact on the system is now a more significant consideration. How parts interact plays a large role in development and manufacturing.

Hypersonics is an important emerging field. Air breathing propulsion is necessary for success in low cost access to space. We need aeronautics to help space programs. An interdependency is growing between Aero and Space.

Why? What is going on in the aeronautics industry today?
Increased fees for environmental impact (such as taxes on emissions) and flight restrictions for both noise and emissions are driving forces. The Europeans are aggressively charging taxes based upon the environmental impact. Furthermore, some nations will soon restrict landing based upon environmental impact. These issues must be addressed if we are to compete in the European market.

Safety concerns play a role. The traveling public is becoming less tolerant of accidents. Liability costs are large. The cost of an accident to the industry is large, regardless of whether life is lost or not. This includes the cost of delays, lost ticket sales, repairs, liability, etc.

These factors make the industry less willing to take risks. More testing is being done that is geared at the safety of technologies, parts, and systems.

We have a much older fleet. Both aircraft and engines are aging. This issue needs some focus due to its profound impact on the safety of the fleet.

- materials (hi-temp)
- propulsion
- manufacturing (see more companies go this way)(integrated product and process development (IPPD))
- IPPD - as a way to make product more affordable
- not sure about rotary wing/helicopters - would need breakthrough in operating cost and reliability to see it takeoff
- VSTOL - vectored thrust got more interest can go well beyond Harrier
- economic argument still not there for high-speed flight.

Basic research is out and the focus today is on applied activities with a short development cycle. The emphasis should be on the subsonic regime with the main problems being airport capacity, the environment, manufacturing process and maintainability. Another area that is important is better , more effecient use of airspace

The military concentration shuold be on operating in remote environments and taking advantage of the information technology explosion. Military research will emphasize materials and propulsion.

Did not understand access to space as part of aeronautics except as a platform?

It is obvious that in 96 we cannot afford to do everthing; Cost is the paramount issue and we need to develop a sort term strategy as well as a long term plan
Need to focus on manufacturing and tooling process
Finalze designs before metal cutting-new process
More simulation less testing
NASA needs to determine why STOLs and VSTOLs have failed in past
This technology needs to be brought to market
We have already lost commoter market to offshore interests
Military still wants faster, higher, farther
Need Hypersonic technology
In 1960s X-15 was supposed to test Mach 8 Scramjet. This was never done and the technology appears to have been lost. We cannot afford to let this happen again. NASA needs to keep up R&D in critical technologies
Aeronautical R&D continuity is extremely important
Unmanned tactical aircraft, and virtual cockpit are military desires.
Large wing, 800passenger, tailess aircrft technology
SST is an economic disaster
HSCT faces seem fate plus the “greenies”

Critical technologies - 1. High speed civil transport and the technologies associated with it. (environmental - noise, emissions, etc.) 2. Hypersonics (military) and the technologies that go with it. 3. Lower costs access to space.

- High altitude sensing platforms to monitor environmental conditions and provide other high altitude applications.

it's hard to define today because the principal driver today is cost—more bang for the buck.
**Critical is determined by cost feasibility –do more with less.
the focus on traditional technology shifted from performance to manufacturing ability. NASA's mission requires that it does the basic work, but the focus also needs to be toward cost.
Relative importance is hard to measure--**micro-electronics—more important than 10 years controls.
**What's missing today is the integration of systems and concepts . 1930's -1940s need for airflow data, → NASA filled this basic need → airflow design made easier.
to improve today's aircraft we need more integration--**synergism—the gains today rely more on synergism of system. System integration and design—more important than the fundamental technology.

The change from analog to digital communications.
Propulsion advances have in the past driven breakthrough for aeronautics, GAP will hopefully prove to deliver a breakthrough for the general aviation market place.
The air traffic management partnership between FAA and NASA is a good one. The FAA has not proven itself at doing research while NASA has.
Human factors research is not being addressed. When it is studied, it is focused on large cockpit crews. GA cockpit interaction needs to be addressed. Ames might have a study done already but this information has not been transferred to industry.

Critical Technologies - propulsion improvements are key to the success of GA. engines and fuels are the critical technologies for GA.

Information technology as applied to aeronautics
Composite matrials
Advanced flight controls
Advanced ATC
HSCT

Propulsion - fuel consumption, performance
Aero mechanics - Effeciency, handling qualities
Structures - manufacturing

Safety: Continue core Human Factors research. There is no current funding to the level it once was.
Advancements in engines is a very expensive thing to do, industry need help and support from government.

Miniturization
Robot vehicles
Active systems
    Dynamics
    Acoustics
Rapid protyping
    HW & SW (SW represents 30-60% of helicopter cost)
Simulation
Basic aerodynamics (Some Russian airfoils are better than US)
Central fusion of electro-optics
National Airspace

Commuter airlines
GPS needed for Free Flight (NASA should be more proactive)
FAA and NASA should combine to solve NAS problems
No one doing the systems engineering
Materials science
Graphites with stress
Micro-miniturization of activators
Propulsion
Reliability
Fuel consumption
Fuel cells
Civil Tilt Rotor

3. Who are the key players in the global aeronautics industry today?

Manufactures: Boeing, Airbus, Prat & Whitney, GE, Rolls Royce, McDonnell Douglas (commercial?, military+), Lockheed Martin (military)
Airlines: United, American, Delta, Southwest, AirFrance, British Airlines, JAL
Agencies/Governments: NASA, DOD, FAA (?), NTSB, Congress/White House, Japan

Commercial: Boeing, Airbus, Pratt, GE, Rolls
Military: Lockheed-Martin, McDonnell Douglas, Europeans (Europeans might integrate more, country pride will keep them in the market place)
Airlines: Huge players, they dictate the market.
ICAO: Other regulatory agency from other countries could start demanding unique box to fly in there airspace which could lead to an increase in cost.

Boeing, Airbus, McDonnell Douglas

Commercial: Boeing (commercial manufacturing is going to be the wave of the future over military)
Military: Lockheed Martin
Airlines: United (key airline) and American
World: The US is ahead, and we should pull away form our competition in the future, the reason being, our productivity and NASA.
General Aviation: Cessna

Large Manufactures: Boeing, Airbus, McDonnell Douglas
Airlines: American, United, British, AirFrance, commuter airlines can not be over looked
Russians: Lack of capital has really hurt them
Helicopters (US): Bell, Boeing, McDonnell Douglas, Sikorsky
Helicopters (INT): EuroCopter, Westland, Mil - Kanof (Russian), Agusta
Pacific Rim countries are developing their skill base quickly and could become key players soon.

The power resides with companies, not government.
Military: McDonnell Douglas, Lockheed Martin, Northrop (they might survive)
Commercial: Boeing, McDonnell Douglas (?), Airbus
Airbus: They have some problems, they have been financed by European governments so far but this funding will end some time and they will have to compete on their own merits. This real environment will hurt Airbus's competitiveness.
Infrastructure: American universities and the support they receive, and give, to NASA.

NASA: Lost right now in the market place, they dominate: wind tunnels and exploring new technologies.
Airlines: They are setting the requirements for the market place, industry must be responsive to the airlines.
FAA: They must be brought into the fold to allow the process to be sped up.

Japan: subcontracts (wing design)
Indonesia: will start manufacturing low end commuter aircraft soon
NASA: Intentions to be a key player, but must identify where they fit into industry, industry
Airframers: Boeing, McDonnell Douglas, Airbus
majors are also trying to figure this out.
FAA:

Boeing (#1), McDonnell Douglas, Lockheed, Northrop Grumman, GE, Pratt, Rockwell, Raytheon, Avionics houses.

Airframe manufactures: Boeing, Douglas, Airbus (which is work very hard for market share)
Military manufactures: Does not have any current knowledge.

Airframe: Boeing, McDonnell Douglas, Lockheed, Government
Government: Too much capacity, too many labs, because of large DOD budgets, labs were built all over the country to assure congressional support.
Europe: A thin line between government and industry.
Japan: Wants to get more involved in the industry.
China: McDonnell Douglas tried to align with China by establishing manufacturing facilities in China.
Russia: Until they figure out how to compete in a market economy they are not a real player.

Russians- well educated, good facilities
Japan
Europe - Airbus
Smaller countries i.e. Indonesia, India coming on.

NASA

DOD

FAA

Universities

The industry's air frame manufacturers are also playing a large role.

It is important to consider avionics. This is frequently left out of analyses of the industry.

The major airframers seem to be concerned exclusively with cost. It is not clear that what we do well can contribute directly and significantly to reducing the cost of RDT&E, production, and operations for the aircraft. Must we redirect our entire R&D program to address the development of "cost reduction technologies?" Industry must take a lead role in this area to identify the high-priority drivers of cost and development time. They are closer to the problem and can better identify solutions. NASA must stay focused on what it does well. A NASA program for design process improvements must attack the major technical barriers which affect cost and development time for the industry, not the second- and third- order issues.

Boeing , McDonnell-Douglas, Airbus

Comment What happened to PANAM?
Lessons Learned
Why does industry operate so close to margin? 2-4%
Load factor gone from 50% to 75%

The French/ German or European combination are important as well as the Japanese. The European combination has tremendous leverage to effect national purchasing. Furthermore, in other nations purchasing decisions are not made strictly on an economic basis.

In the future, in Korea, Singapore, and other Asian nations where there is high quality automobile production, important centers for aircraft production may arise.

Engine companies also play an important role because they are getting better and better at cooperative development and joint efforts.

In the commercial sphere, Boeing may object to things they cannot or will not use because the technology may be sold to Europe.

McDonnell Douglas is a major player for military aircraft. It has become well coordinated and have a phantom works (skunk works plus applied R&D). Overall, McDonnell Douglas' technology applications are getting better. Lockheed-Martin, however, is still fighting itself over the merger and submitting multiple bids for the same work. This is detrimental to Lockheed-Martin.

There is a diverse group of players in the aeronautics industry. DOD and NASA are major players. The Europeans are getting closer to having a federal agency of their own equivalent to NASA. It would give such an organization the resources to be a major player. The primary industrial players include manufacturers such as Boeing, Airbus, Pratt& Whitney, Rolls Royce, and GE. Lockheed and McDonnell Douglas are major players on the military side. Aerospatiale is a major player. If the Russians ever get their act together they have potential to be major players.

High barriers to entry (capital investment and technology), yet an attractive industry. The industry is not sufficiently competitive to get Wall Street backing.
The industry has gone through its consolidation phase. Will probably have the same companies as today be key players. There are probably small enough players so that the government can keep the industry healthy.
Internationally, Boeing, Aerospatiale and/or an Asian competitor in the airframe business.

For civil, it's the three major airframe manufacturers (Airbus, Boeing, Douglas), the three major engine manufacturers, airlines, and government regulatory agencies. For military, it's the Pentagon, USAF, and industry. Russians are not major players but could learn. The market could disappear faster than they could learn the technologies.

The major players are the manufacturers: Boeing, Pratt & Whitney, GE, and Rolls Royce. Lockheed-Martin and McDonnell Douglas are military. It is hard to tell how they will shake out in the future. Airbus is also becoming a major civilian force.

The avionics houses are often overlooked as players but they increasingly will play larger roles. Honeywell and Collins are the major firms.

NASA is a major player. DOD's role is declining because its R&D budget in aeronautics is getting smaller.

NASA aeronautics is handicapped by the Shuttle and Space Station.

The airlines may have more influence than in the past. What they decide to buy may really reshape the manufacturing sector. The airlines are getting better at knowing what they want to buy.

FAA has a small role. Universities had a larger role than today. Their role is declining because of the limited research funds.

FAA is a strange agency. It needs to be highly involved in R&D but it is not. Its operations costs keep increasing. As a consequence it has not devoted much money to research. But research is the way out of FAA's problems. Right now the FAA's major problem is that it cannot adapt to the rapidly changing air traffic environment.

Key players are Boeing, McDonnell Douglas, and Airbus. Airbus is doing a lot of things right that we're not doing, like wind tunnel development. Airbus has "overcome its nationalist tendencies" and are operating more "seamlessly."
The Japanese are another key player. Japan and other Asian countries such as Indonesia are investing heavily in aeronautics - for example, they're trying to develop and build small commuter aircraft. Roy speculated as to whether there's the potential for Russia and Japan to collaborate on aircraft development. Synergies exist, he said, but they have to overcome cultural barriers.
The FAA is a major player and a major problem. It's politically impossible to build new airports (NIMBY syndrome, etc.) yet several airports are nearing saturation. This needs to be solved.
Safety will become more of an issue in the future as air traffic management gets squeezed. Soon, it will become increasingly important to communicate to the traveling public that the reality is that air travel is safe. As air traffic grows, if we simply maintain the same per capita safety rates, there'll be an aircraft crash every month instead of every year or so like today. To compensate, we'll need to achieve unheard of levels of safety to maintain public perceptions that air travel is safe.
Pressures for change: if we don't make the investment to achieve safety, Airbus will. The US is under pressure to change and is at risk to lose significant clout if it doesn't act soon.
The aeronautics industry is a major source of tax revenue. If the US loses aeronautics as a primary industry, there are government revenue and balance of trade implications.

Airplane manufacturers;
End drivers are the commercial carriers and what sort of equipment they want.;
ATC infrastructure: the growing market for aircraft is overseas, and the size, and type of plane depends on the capacity of ATC systems in other countries.
The markets are in Asia, so should upgrade the ATCs in Asia--***must have capacity in ATC → capacity in airports, capacity in moving people.

Capacity could be a potential for NASA—it has more R&D in ATC than the FAA—the challenge for NASA is addressing the problems of its customers. The basic problem in ATC is not technology but 20,000 ATControllers that must adapt to new tech →*Human performance problem.
FAA has is $8.9 billion/year organization, with a $185 million R&D budget—60% of which has nothing to do with ATC. You can't introduce new technology without "buy-in" from ATCs.
***The REAL challenge is to introduce new technology into the system. This is a real problem because there's a lot of technology. So not waiting for the breakthrough because already have it.

What we're waiting for is the deployment of the technology → introduction of the technology to industry —to get industry to use it. This is a people problem: a parallel comparison to the auto industry.
The problem is not the product, its who's going to use it, and who's going to pay for the R&D. Technology is only a small part of the problem. Easy to say the problem is no technology breakthrough. Contributors to the problem: traditional engineers, techies.
EX: the Clinton administration is big on maglev trains—Moynihan is a big supporter of maglev—they all think that the answer is the maglev train, but haven't gone through the exercise of determining why its the answer and how to accomplish it etc. Problem: who's going to pay for it and who's going to ride it.
Process and the handling of human capital is key.

Key players are operators, designers, builders and government:
Research base: a group involved in development and application
Airlines
Is NASA listening to them? NO. Need an improvement of communication between the end-user and the sci-engineering community.
Maintenance operators

The military: operating and war fighters—need to be convinced about the new necessary systems.

The commercial sector: the customer is king. Commercial passengers will hold all the cards. In the past, a relatively small part of the public flew. Today, more of the public flies, so they have clout. The media plays a role in informing the public about low prices and safety concerns etc. Air transport is taken for granted so there is a demand. Air transport keeps making the world smaller and smaller.

As demand increases, it will not be satisfied by making planes bigger and runways longer. **Instead the industry will need short haul terminals to alleviate all the congestion.

Airbus, Boeing, McDonnell Douglas, NASA and DOD.

The key players in the industry are Europe and the United States. Europe is included as a key player due to two consortia, the military and civilian. The Russians and the Japanese are lagging too far behind in order for them to be considered key. In fact, the Russians are more of a market. In addition, they could provide the capabilities for offshore manufacturing. However, they currently do not have the infrastructure to be a competitor with Boeing and Airbus.

NASA is not a major player. In the 1980s, a proposal was offered to close the Lewis research center. Industry took no action in order to oppose the proposal. Industry benefits from NASA. However, it does not consider NASA as a crucial member of the aeronautics industry. This is the case in spite of the fact that industry is currently conducting very little research. Pratt & Whitney, Boeing, and Lockheed-Martin all closed their research centers. GE continues research, however it is one of the few retaining it's research capabilities.

There is tremendous competition from overseas. The link between industry and government is closer overseas such as with European consortia like Airbus.

An example from the space industry is communications satellite launch affordability. Our industry focuses on its interests rather than that of the customer. However, overseas the customer's desires and needs are foremost. This has detrimentally effected the U.S. satellite launch market. Similarly, Aeronautics must respond to the needs of its customer.

The key players are Boeing, Airbus, McDonnell Douglas, Lockheed-Martin, Pratt and Whitney and GE. There are also bit players such as NASA. In the rotorcraft industry NASA is a major player but the rotorcraft sector is only about 5 percent of aeronautics.

Our goal should be to avoid being a captive of any one firm in industry. We should adopt a role of doing research that any one of the firms alone could not afford. This is the only way we should subsidize their research.

Boeing
The Air Force
NASA plays a key role.
GE and P&W would also be in this category.
McDonnell Douglas would be included but he is not sure how key they are.
Airbus
The German Aerospace market
Japan

Key players are Boeing, McDonnell Douglas, and Airbus. Airbus is doing a lot of things right that we're not doing, like wind tunnel development. Airbus has "overcome its nationalist tendencies" and are operating more "seamlessly."
The Japanese are another key player. Japan and other Asian countries such as Indonesia are investing heavily in aeronautics - for example, they're trying to develop and build small commuter aircraft. Synergies exist, he said, but they have to overcome cultural barriers.
The FAA is a major player and a major problem. It's politically impossible to build new airports (NIMBY syndrome, etc.) yet several airports are nearing saturation. This needs to be solved.
Safety will become more of an issue in the future as air traffic management gets squeezed. Soon, it will become increasingly important to communicate to the traveling public that the reality is that air travel is safe. As air traffic grows, if we simply maintain the same per capita safety rates, there'll be an aircraft crash every month instead of every year or so like today. To compensate, we'll need to achieve unheard of levels of safety to maintain public perceptions that air travel is safe.

The end user is the ultimate customer. It is difficult to determine NASA's customers: DOD? Airlines? One can't say.

Passengers who want to use air travel. What will they accept from the industry and what are they willing to pay for?
Airlines are very risk adverse and managed by people conscious of the next quarter's balance sheets. This is contrasted to earlier days when you could make a deal on a handshake.
Manufacturers of both airframes and propulsion systems want to provide a product. They need to be encouraged to take a little more risk and think more. They are beginning to sell package deals for engines and their maintenance.
FAA promotes and regulates the industry. They must balance these two responsibilities. FAA must also balance environmental concerns with economic health.
The military--DOD and the Pentagon-- must meet its future needs with a declining budget and an uncertain international climate where no one knows who the enemy is.
Effective intelligence gathering in a timely fashion means aircraft and infotech must complement each other.

Boeing
Airbus
The Russians
GE

RR
Pratt & Whitney
SNECMA
DOD
FAA
Second Tier:
Component suppliers
The Japanese
Rockwell
Northrop- Grumman
Electronics and Avionics industries
Specialized materials industries
Design & Test industries / facilities
GPS / MLS suppliers
AA, SW, BA, JAL, Lufthansa
Fed Ex and other cargo innovators
Germany as a wild card
Burt Ruttan (and other innovators like him)
MIT
Lockheed-Martin (in the future)

I think NASA plays a critical role in helping industry consider the viability of advanced materials technologies. Industry does not have the facilities, personnel and funds to do this high risk research.
NASA can be the team leader, facilitator or catalyst for innovation in the industry.

French industry - inventiveness
Germans - manufacturing
British - propulsion - leading the U.S.
Rolls Royce leading P&W and GE in emissions and noise
Japan - high temperature materials - mostly supplier, not designer
Boeing - leader in export industry - too conservative in aircraft design
McD - good military technology
Foreign airlines - not U.S. airlines - (they are not innovative thinkers) - in general not big drivers.

The players today are Boeing , Airbus and the Airlines. There is a strong desire by 3rd world companies to have their own a/c company

European competition call for a national policy. We need an industrial policy to keep US companies competitive.

Russia is leading in technology in some areas.

Skills? There is a shortfall in education in folks becoming engineers and scientists. **looking at kids who can afford to go to school only, so those hat can go to the expensive schools are the ones being recruited. Industry needs to tap kids at junior colleges, and women also. Europeans take kids that show promise and educate them early on. Kids coming out of school with technical backgrounds with two year degrees are very employable because there is such a shortage.

US is still the most active in the world and still leads other nations, Europe is a significant player and are very environmentally aware. Japan (Pacific Rim) are on a terrace below both the US and Europe. Both China and Russia are a level below Japan.
Airlines dominate the world market today and they will dictate the aircraft of the future.

Manufactures: Boeing, Airbus, McDonnell Douglas
Airlines: Depends on interest, they have limited interest or knowledge on issues. FedEx has been willing to contribute to some research.

Malassia, Indonessia, Austrialia, and South America are all starting to manufacture small aircraft. Japan is currently studying the industry and might join. Russia has the wide open spaces but does not have the capital to be a big player. It is hard to see China openning its skies to small planes flying all over the country side, so they are also not a big player. 1/2 of all the flying in the world happens right here in the US, this makes us the largest market for small planes. Currently 30% of US small aircraft sales are exports, this number will drop if we could fix our infrastructure and increase as US demand for new aircraft.

Key players - no on is in charge, not ICAO certainly. US Airlines have been leaders in implementing technologies through operational testing. Some government CAA officials have been instrumental in implementing new technologies.

Users demanding airlines who in turn request NASA support.

The Aviation industry as a whole. The industry is now taking the lead to push technology over from government, except in the field of long term research. Countries: US, Europe, Russia, India, China, Japan.
Regulator organizations, such as the FAA and JAS must maintain the air traffic system.
The Defense department is the key player in developing new aircraft technologies and flight regimes.

NASA- help with high risk technology - regulations are hampering application of advanced technology
FAA - restrictor, not encourager
Boeing, Douglas, Airbus
Honeywell, GE, Litton (Avionics mfrs.)
Navy getting out of aviation research
Military research is so sophisticated, not of much use to general civil public - missions are not compatible with civil world - biomedical suits
DOD - not interested
UAL, AA, NW, Delta
Need a new process of certification, some things are not necessarily testable
Liability issues limit introduction of new technology
Interaction is more than before - economics drive all
Working reasonable well
International harmonization of regulations is proceeding

Boeing regarding commercial—Boeing is not a bashful company. It has plenty of leverage in being able to get governmental R&D funds channel to it; McD is trailing behind
Airbus is a match for Boeing. Boeing has exploited economies of scale and some technological advantages to keep up with Airbus. In 1994, Airbus matched Boeing in orders.

At the expense of McD, Boeing has held market share. Lockheed continues to export.

The airlines, United, Delta, British Airways and Luftansa, are large players.

The Japanese are playing a larger and larger role. The Chinese are also starting to have an impact. This is due to their purchases of a lot of aircraft to service the booming Pacific Rim market. Both of these markets demand high quality from their aircraft.

Airframe firms such as Boeing, McDonnell Douglas, and Airbus are playing a role. Others, such as Lockheed-Martin, would like to diversify into the civil aeronautics market. They are interested in partnering.

Engine firms like GE, Pratt, Allied Signal, SNECMA, and Rolls Royce are important players.

Governments are also major players. NASA is a big player and it has considerable influence. The European counterparts to NASA (DLR of Germany and ONERA) are also playing a role.

Universities are becoming more of a partner for development. The influence is obviously there, but Universities are not "movers and shakers."

ICAO plays a role by setting emission and noise standards. Such organizations, as well as environmental scientists, give an independent viewpoint and drive research.

Congress also plays an important role.

Guiding player - manufacturers - Boeing does what can do, aircraft companies adjust at edges.
- By Boeing mean “front office” not just engineers
- PACRIM - growth market - Boeing not going to bet company unless numbers reflect their analysis of numbers (engineers and marketers)
- Strength for Boeing over Aerospatiale - Aerospatiale higher political content than Boeing, opens them to more opportunities to make bad decisions.
- Proof - conclusion to build 747 after lost C-5 program

Industry Boeing, McDonnell-Douglas, Airbus
Countries US, Europe(Ger,Fra,Eng),Asia(China,Japan,Korea)
ATC FAA, Lockheed-Martin-Loral, Raytheon
Airlines AAL,UAl,DAL Note Airline collaboaration is key to future survival

Civil
Boeing, Airbus, McDinnell-Douglas
Military
Lockheed, McDonnell Douglas

Note: F-15 will not be retired until 2024

4 major companies: McD, Boeing, Lockheed, Northtrop. Capable designers, commercial and military. What’s missing is eyes for the future.

**Resources to concentrate on fundamental technological and integration. Industry is not focusing on R&D the way they used to. There’s survival mindset, and that’s cost saving. The future depends on R&D but if you can’t get to the future it really doesn’t matter. Resource base of engineers is eroding—over last 10 yeas actual dollars are going to R&D is decreasing. Engineers going into other industries and other programs.

**Export markets—the viability of the industry is dependent on exports.

GA- The number of pilots is the driver, in the short term there will be a need for small trainers but in the long term there will be more of a need for big aircraft to be used by corporations and charter groups. Regulations are a major restrictor to this market.
Business Jets- The US economy is the driver and is very influenced by new technology (GPS,..). The new technology added effects the value of the aircraft.

Commercial- US economy is the driver, very cyclical in nature. The government regulations are a restrictor to the market place, not a stimulator.

Key players - Today's scenario is that the aeronautics industry is leaderless today. Airlines and Airframers have less power now. Controllers union has grown in power. (Kind of Mexican Standoff). The consumer is at risk if someone doesn't take charge.

Government
Air framers- Lockheed-Martin, Boeing, Airbus, McDonnell Douglas
Engines: General Electric, Pratt and Whitney, Sema

Boeing	GE	BA	Embraaer
Airbuss	Rolls	UAL	ATR
Douglas	Pratt	Singapore	SAAB

Boeing
AF-Navy combine

Countries: US and Europe, lower tier: Japan, Russia (if they can keep from falling apart)

Transport	Helicopters	Engines
Boeing	Sikorsky (40%)	P&W
MacDac	Bell	GE
Lockheed-Martin	Boeing	Allison
Northrup	McDonnell	Garrett

How do the key players interact?

Somewhat of a fickle environment, the interaction varies as the government's politics change. There are more multilateral agreements rather than bilateral.

The interaction is much more complicated, a lot more goes in to optimize an aircraft.

In Europe there is a lot of teaming being done today, US industry is not so there fore has a lot of redundancies in research.

Commercial industry and NASA have to work more closely together. They should look at NASA as their research wing.
Military and commercial industries will never get to close, technology transfer only goes from military research to civil use.
The FAA is required to set the noise requirements and air traffic management, they must work with NASA to solve these issues

NASA does not have a very good model, until very recently the two majors (Boeing & Douglas) were fighting to see who would have the next major airframe to market, similar struggles were seen by the two major engine manufactures (GE & Prat). NASA is not a major player.
NASA needs a new model to prevent another Japan-Automobile kind of occurrence from happening.

There is some interaction amount the key industry companies, ITLT , a group of industry that meets with congress do discuss issues.

Douglas has gone down twice and is willing to share technologies and is looking for expertise, however Boeing is not so willing to share technologies or expertise, but they are a lot more open now because of the inroads made by Airbus. Douglas has the better researchers but Boeing has the better integrators of technologies.

Players are starting to partner on large projects. Player interact very carefully however. Middle management communicate freely but bureaucracy can get in the way the higher up the corporate ladder communications travels.
Can not divorce the technology from the politics.

There are formal agreements that bind NASA and the FAA or NASA and the DOD. Cooperative R&D agreements (CRADA) exist between NASA and the DOD. There are reviews of NASA relations with universities. However, nothing is done about resources as a result of these reviews.

Who is the customer? We need to be leery of Boeing led projects. We also need to be conscious of the pressures that can be exerted by the American taxpayers.

Technology of aviation moving too fast for ICAO.

GE and Pratt are working better together than they do with Boeing. Boeing has a tendency to subjugate its subcontractors.

HSR teaming is spending more time learning to work together.

However, to a certain extent, Boeing controls the playing field.

Overall, the players work quite well together. These efforts are being driven, to various degrees, by engine firms that are trying to protect their own survival.

There is a competitive and complex set of interactions among the three major airframe manufacturers who compete globally for market share, but cooperate for safety. The engine manufacturers play a leveling role. They don't care which aircraft manufacturer they sell to.
[GE] leaks information to Airbus to gain market share.

International standards are a major factor in shaping the role of the players. So many countries fly in the airspace of others that the most stringent requirements tend to set the airline standard.

If the government agencies are broken down and doing the same type of research it will create "proposal competition". Ex: NASA and other government labs doing similar R&D, for instance the FAA has had a mandate to promote the air travel system, air travel, which questions the relationship between NASA and other labs, because they are called on to evaluate proposals and determine who gets the business, which leads to an industry dilemma—how can industry approach the government with a salesman hat and yet need to ask them for help to solve problems. To complicate matters, NASA is asking industry what it needs. It's a delicate balance.

The main reason for the failure of the wind tunnel proposal was the lack of consensus from industry(McDonnell-visionary, Boeing- conservative). High speed research has good communications at the working level but poor at high levels.
Cooperation is of increasing importance in this era of tight spending.

If industry had a vision beyond three to five years, they would need and value NASA much more so than is currently the case. Industry could cooperate and task NASA with the research portion

to extend their sights past five years. The corporate VP of engineering would know and support NASA, however the corporate President would not know any of the center directors.

The FAA is another institution that has not had any major interaction with NASA. For instance, the FAA gave $350 million to Mitre Corp. NASA on the other hand received only $20 million in addition to some moral support. What FAA should do is reconsider its allocation of funds.

Overall, interaction between NASA and others in the aeronautical industry is quite limited.

The interaction among the players is defined by the market. The actors cooperate when there is a market advantage for doing so. A dominant player such a Boeing has few incentives to cooperate. We run the risk that NASA will become an adjunct of Boeing's market strategy. Our relationship with Boeing is much different than with Douglas. If Boeing has an advantage in a technology it tells us that the technology is not very interesting for future business and that we are just wasting our resources by focusing on the subject.

There is more cooperation than there had been in the past, but it is still limited. Boeing plays its own game and focuses on its own agenda. It is not a team player.

P&W has in the past invited representatives from major airlines to talk about the future of the aeronautics industry. These meetings are not held regularly and but are very well received. (It is essential that we meet more often).

Airlines and NASA Aeronautics work reasonably well together. There are some adversarial aspects, but these are mostly sales environment issues.
The FAA is adversarial at times. It wants to be more collaborative, but that is difficult given its two roles.
Airframe and engine manufacturers are becoming more cooperative. Propulsion has been recognized as an important factor in selling aircraft. There is a partnership coming between airframe and engine manufacturers.
There is more collaboration between NASA and industry which is taking the two to a higher plateau and continuing to work for the future.

The interaction among the key players is best described as intense competition mixed with joint protection of the industry. Among many key players the competition has frequently shifted to non-price competition. This may be in services, or in political and social areas, or technology transfer.

Some other aspects of player interaction:

- More interaction among airlines and manufacturers.
- After-market sales are VERY important (esp. in engines)
- Better communication between manufacturers and NASA
- NASA - FAA relationship has become important wildcard
- Suppliers gaining more power (auto industry analogy)
- Less “guild-type” approach in mfg. – more interaction between designer and mfg.
- Growing departure between small & large transports
    - Market geography and demographics is causing a new shift in the market for small planes

Not very well.

All of the US companies benefit from NASA technological.

There is going to be continued consolidation among producers. More joint projects.

What role do governments play?

Government is still sustaining this industry because of its importance to national security but understanding that consolidation is inevitable. Japan looks at this industry with monetary returns in mind, Europe is looking for social returns (i.e. maintain high paying job in the economy).

Government R&D has dried up in recent years, this has hurt DOD, FAA, NASA and universities.

He feels that the corporation between Airbus and European governments is not "fair". The types of agreements that the US government has with our industries are more legitimate.

Facilities and resources can help industry focus and team which would help reduce redundant and wasteful research.

NASA/FAA: Terminal control research

DOD is doing most of the defense related R&D but is relying on NASA for non military technology and non weapon system flight testing.
US - Russian hypersonic research project.

US is subsidizing US industry through direct support and wind tunnel testing. NASA needs to maintain their relationship with industry but needs to shift its focus to technologies that are 5 to 10 years out.

Long term, high risk, high payoff technology.

FAA and NTSB do not have a well organized and efficient R&D capability. Both are agencies which are critical to the future of the U.S. air transportation system. However, they respond to but do not anticipate problems. NASA should take the longer view and complement their efforts.

US is still most powerful
- Must push technology development others will follow

Amount of fossil fuel is limited
- Prioritize usage airlines vs lawn mowers
- Reusable energy sources

In the government, the major players are NASA and the Air Force, but not the whole of the DOD.

NASA as the primary government agency in this policy arena has a role of assisting American industry in establishing superiority for U.S. aircraft and engines. NASA is in competition with foreign governments attempting to make their industries more competitive.

Airframe manufacturers rely on government regulations.

It's looked to for safety: the guarantor of safety, ATC and navigation systems are the expected roles of the government to reduce accidents, so that role will get bigger.
As ensuring/creating jobs and promoting free trade as going to have a big impact on aeronautics government is going to have to do the long-term research to compete with foreign competition.

Europe and US have differing government roles, but are similar. US support of NASA is viewed by Europe the same way we view Airbus. Governments are the funding source.

Are they all subject to the same pressures for change?

Commercial: economic, not performance pressures.
Military: Government is going to fixed cost contracts. The threat has changed from one to many smaller ones.

Causing researcher to work a lot of closer to developers so that there is a shorter cycle development time.

Europe faces different market forces because of the desire and willingness to use public monies to protect public jobs.

However, Boeing is less subject to government interference than European firms.

Pressures for change: if we don't make the investment to achieve safety, Airbus will. The US is under pressure to change and is at risk to lose significant clout if it doesn't act soon.
The aeronautics industry is a major source of tax revenue. If the US loses aeronautics as a primary industry, there are government revenue and balance of trade implications.

Who is at risk? Why?

The FAA, with all their problems, the FAA is not getting the R&D moneys it needs. They have a credibility issue. They are at risk of being privatized and separated from DOT.
NASA aeronautics has no clear role and its budget is so small they run the risk of having it zeroed out.

McDonnell Douglas was at risk but new leadership has done a great job to strength the Douglas side of the company.

NASA: Needs to invest more into group projects, they need a single vision of aeronautics NASA wide. In the past they have tried to make everyone happy, when budget cuts came down from Congress they would cut every project across the board. NASA needs to prioritize research and completely cut some programs. NASA's research in the past has not been consistent, it varies as political leaderships changes, in the future NASA needs to be focus on a few projects.

Possibly losing both a airframe and engine manufacturer.
NASA is at risk; the country is focused on near term and if it is perceived that NASA is not providing this near term support to industry it is at risk of dying.
FAA is also at risk because of the inability to develop new technologies and handle the growth in air travel.

Government Agencies: Both DOC and DOE are on shaky ground, might be eliminated by Congress.
Corporate Industry: A few more mergers are possible and the number of helicopter manufactures will most likely drop from 4 to 2.
GA: Who knows.
Propulsion: There will be no change in the big two (GE & Prat).

Most at risk: US companies, other companies are so connected with there government.

The FAA is in trouble. A restructured FAA will emerge in the near future. Specifically, FAA research could be merged with NASA

The rotorcraft program is at risk. Military demand is declining and the civilian uses for rotorcraft are very limited.

We need to learn how to help industry without allowing ourselves to be used as a tool of industry. If budgets continue on their current path, we will have to shut down several or all of the Centers. NASA will not disappear.

Ames is reaching a critical mass. We are losing critical younger people and our facilities are getting older. There is not a systematic upgrading of facilities that will be important if we are to survive and be effective in the future.

FAA is at risk politically
Industry?
Who is making today's L1011A?

NASA is at risk, no question. NASA is perceived as being the most easily expendable. GE and Pratt & Whitney may go away, but that would be by choice.

NASA may lose because transportation is no longer exciting. That will effect national desires to finance the industry. Public sentiment may be why do we need federally sponsored R&D efforts as opposed to corporate or industry funded R&D. We have a national investment the citizens made in facilities for NASA, but privatization could still be a threat. The consequence of NASA privatization for the public may not be discernible. That is the problem.

Government funded aeronautical research, other than for military applications, is questionable.

Assuming nothing new and dramatic happens to the time of air travel, trains may become a threat. This could happen if technology falls down the list of priorities and money for R&D is reduced.

If you look at the future of NASA strategic planning, what we will be doing in 25 years is air breathing propulsion to space.

The image of the industry is one of rapid change. In reality, there has been very little change. There may not be another 20 years left of what we have been doing unless we change focus. (Maybe more focus on supersonics.)

Douglas is at most risk for loosing market share globally.

Among all the players, the FAA is the most at risk. The primary threat to it is that it will be privatized.

Aeronautics at NASA is at risk. especially the work in the future. Boeing, McDonnell Douglas appear healthy with Airbus growing. There is a concern about the shift of power to the Centers with a subsequent reduction of headquarters staff. This might not be good. The budget will go from $14 B down to $11.6B by 2000

NASA is the institution which is most at risk. In difficult situations, several of the research centers are specifically at greatest risk.

The FAA tries to be an enforcement, advocate, and research agency. In fact, it has done a poor job in all three areas. Currently, it is entertaining the idea of turning the research aspect over to NASA or contracting it to an outside source.

Among the players NASA is at risk. This is because if we give industry a choice: solve a present problem or solve problems that create long term potential, industry will always pick the short term option. We could let industry get us in trouble.

NASA is at risk because the Air Force may take on commercial aeronautics at some time in the future. There are some commonalties in the product lines and research focus between the Air Force and NASA.

Pratt & Whitney and McDonnell Douglas will be "gobbled up" by GE and Boeing some day.

NASA aeronautics is at risk because it is perceived as a space agency. Mr. Goldin has been a good influence because he "upset the applecart" which is healthy. There is a strong sense of frustration that U.S. industries have not taken up the technologies developed at NASA aeronautics. The threat is that NASA may invest the money elsewhere. This would leave industry looking for a development center.
Also, the engine industry is at risk because there is not enough money for all the manufacturers given the decreased demand. There is more downsizing coming.
GE and Pratt teamed for supersonics because it is too expensive for either to pursue alone. This will extend to producing the engine in the future. This is a form of downsizing.
There were 3 separate engines developed for the 777. Today, there is not enough work to go around to support 3 engines.
Pratt and GE are also working together to make a new engine for the stretch 747 so that each will see some profit from the venture.
McDonnell Douglas is at risk. It is a niche player that was left in the dust with a limited product line due to its inability to compete with Boeing and Airbus.
FAA is always at risk. The FAA is threatened by privatization or the government may break it into several functional agencies. It must improve to survive.

The country is most at risk in the future. The balance of payments issues must be resolved favorably.

It is hard to say. A few years ago, Rolls Royce would have been considered at risk, however the purchase of Allison saved them.

Consolidation is a trend. Small firms like Teledyne and Williams are at risk because their product is military based (cruise missile engines and other missile engines). Small engine firms are at risk. Piston engine firms such as Continental and Lycoming are at risk.

Honda and Toyota are making a major play for the General Aviation market.

Suppliers for the major manufacturers are at risk because business is going overseas.

NASA is at risk. Balancing budget compromises threaten the NASA budget. Work force downsizing within NASA is forcing it to develop a tighter focus. This may play itself out in a Space vs Aero competition. Is Aero visionary enough? Does industry use technology aggressively enough? For example, Airbus used the NASA developed wing, but Boeing will not use it. Airlines do not want new technology put into aircraft because they need low risk and low cost strategies.

Airlines are at risk due to consolidation. The need to maintain low costs also pressures the airlines.

NASA aeronautics is shrinking to a point that major aspects of it will go away. NASA is under strain to maintain shuttle flights, build the space station and develop a new launch vehicle. This will squeeze aeronautics with propulsion being hit the hardest because the facilities to do research just are not in NASA any more. DOD might take over aeronautics and run it from Wright Patterson Air Force Base.
McDonnell Douglas will not make it, leaving only Boeing and Airbus.

4. Now thinking about the future, what do you think the global aeronautics industry will look like in 25 years; how will it operate?

More of a global model for both airlines and airframe manufactures.
More efficient HSST's.
High speed rail in direct competition with tilt rotor aircraft.
Airframe manufactures will become either integrators or suppliers, with more leverage in the hand of the integrators.
About the same number of airlines.
Space, questions if it will be a big player in the next 25 years, but could be if a market could be Created not captured.

With the population growing world wide, this is going to drive everything. We are about to hit a wall as far as being able to handle more of a load on infrastructure. There will be more problems with natural resources and pollution in the form of emissions and noise. With the increase in fuel cost efficiency is going to come back as a key drive along with alternative fuels.
Air Cargo is going to increase, along with personal travel, dependent on price. Business travel is going to drop off with the expanded use of video conferencing, but international travel is going to increase. Demand for air travel will increase at a rate faster then the population.
To handle this higher demand for air travel the only way to go is to build larger aircraft.
The ocean routes have a lot of room from improvement as far as capacity goes.
In the future there will be fewer manufactures but those that survive will be more global organizations. The industry is treating aircraft as more of a commodity now, and this will continue into the future.
Air traffic management will need to become standardize world wide in the future.
There will be a completely unexpected, new engine cycle or fuel.

There will be the entry of possibly two more major competitors into the market place, Russia and one of the following: Japan, India, Indonesia, or South America.
There will be more intermingling of international airlines. This is going to be especially true is a HSST is going to be built.

There has to be a harmonizing of the aviation system. AKO in Europe has done a lousy job and with the emergence of third world countries there is going to have to be a standardization of air traffic.
In the US 75-80% of the people have been in an airplane, right now only 2% of Chinese have had this experience. In the future their numbers will begin to approach those of America, so this is an area of tremendous growth potential.
There will be no military adversary to the US. The threat to the US will be in the form of terrorism. The military will have to invest in quick response technologies to handle this type of threat and this will dictate the types of aircraft developed.

General aviation will deminish because they will have to compete for airspace with commercial carriers and the cost of equipment will be too high. GPS might changes this however.
If the US can not build more airports the aircraft will become much larger, 1000 - 1500 passengers.
Hub and spoke might fall out of favor, more point to point flying. Denver International Airport has already notice a reduction in flights because more are choosing to fly directly into the mountains to ski resorts.

There will be fewer air carriers, transport aircraft will be able to fly half way around the world at near supersonic speeds.
There will be better air traffic control that will increase the capacity for aircraft, especially trans ocean routes.
Does not believe there will be super jumbos because there is no infrastructure to support them.
There will be more intermodal development.
Helicopters will be quieter, have a lower empty weight fraction because of the introduction of composites, they will be used in hub and spoke short haul operations into airports. Tilt rotor will be used for airport to airport short hauls. There is room for both helicopters and tilt rotor in the short haul market. Helicopters range is about 1 hour flying time or 60 miles, longer then that the tilt rotor will have the market. Because of the information are there is going to be a decentralization of workers, this will increase the demands on the short haul market place.
He see a world wide ramping up for the helicopter industry, not a decline.
There will also be more teaming between US and nonUS companies and an international flavor to all companies as they are forced to recruit from all over the world to find the educated people they need.

There will be more international competition, Japan and China will have capabilities increased as US manufactures contract to them to buy into their markets.
Airports are going to be the bottle neck.
HSST is not going to be viable, speed will not sell and it will not work within the current infrastructure.
There will be a Jumbo transport and an increase in short haul.

Can not address this issue

Boeing will still be the market leader. Douglas may still be in the commercial aircraft business.
Airbus will retain its market share and might increase it somewhat.
There will be 1 or 2 super jumbo air transports built by either Boeing or Airbus.
There will be even more outsourcing of parts manufacturing.
China could be a big player manly building aircraft for internal consumption.
Russia is the wild card, they have good airframes and are now adding on US made engines and avionics.

It will be a very flexible industry that will be able to adapt to and understand better the market place.
Companies will identify high payoff technologies quickly and will be able to identify risk with computational models.
There will be less global barriers because of the existence of large multi-national conglomerates.
There will be a understand of the total physics of aeronautical problems.
The work force will be adaptable with similar computer codes and be able to move more freely from company to company.

Air transport is the most common means of transportation on the planet for everyone with vehicle size and style varying by route.
Free flight.

Structures have not varied much except for the advent of composite fuselages.
Propulsion advances.
Possible advances in aerodynamics.
High speed rail will not be a big player, "it is easier to go over things then through them".
Players dynamics: NASA has to decide when technologies have matured and when it is time to get out of that area.
There are technologies that have been developed in aeronautics that can be transferred to space composite structures.
Air travel increases, information infrastructure could take care of the increase load on the air traffic control infrastructure.

Boeing hopes to stay dominant, but Europe is not going to back off.
Russia and China will be major players.
Airlines will grow like crazy. (Of the 480 airlines Boeing sells to 475 of them)
Open world trade
No more hot or cold wars
Moderate economic growth, More discretionary travel

By 2020, all these seemingly major problems of control of air space will be behind us. We will be able to solve problems faster than in the past. Air traffic control will be much more automated. The human interface will be less of a problem. Humans will learn to adapt to the automatic system faster and faster. Future pilots will not have to worry about whether or not they are flying in the same airspace.

In the future aircraft will have to get more quiet. But the more quiet aircraft become, the greater is the expectation.

Safety will be advanced significantly. In fact, in the near future safety will not be a major issue for the large capacity carrier. It may be in general aviation. Safety is more a human problem.

Twenty-five years from now we will have about the same configuration of manufacturers. Boeing, Airbus, and probably McDonnell Douglas will be healthy because over the next twenty-five years there will be a tremendous growth in air travel. The worldwide market will expand radically although the domestic market for large carriers will not grow as fast. There is a major market in Asia. There will also be a large domestic market for short haul aircraft.

Quite useful for understanding what many academics focusing on the future of aeronautics are thinking is this publication: Future Aviation Activities. Eighth International Workshop in Transportation Research. In Transportation Research Circular, No. 425, May 1994.

I did work with the Futures Group on this issue about 15 years ago. Hal Becker did an excellent job creating scenarios on this issue. You should dig out that report and look at what was done.

It is just not true that airports are not expanding fast enough to meet the increased travel levels. You can hardly name an airport this is not modernizing. But in the future, we can expect private sector control of airports. Unfortunately, today Federal rules limit what cities can do with profits. If cities could use airports for general revenues they would expand faster. Airports can be a big source of revenue for cities. Laws will have to be changed.

The one big surprise in the future may be in materials. If we have a breakthrough in materials like the electronics breakthrough, it will completely revolutionize our travel. A new material which could make an airplane light and cheap would radically reduce the cost of our travel and consequently expand the number of users. We have not seen a major breakthrough in aeronautics

since the Boeing 747. I think we will have such a breakthrough. It might be in design technologies.

Demand will shape the future. Military requirements are changing rapidly. Battlefields will be dominated by skirmishes where quick response is essential. Our technologies must work in all environments. There must be a mix of piloted and unmanned systems for the new battlefield and this will pose a battlefield management challenge. We must be able to provide maximum battlefield information with a minimum of casualties. We must also be able to provide flight operations that are unlimited by weather, visibility, and other battlefield impediments.

The civil emphasis will be on maximizing productivity and safety. There will be larger and larger subsonic aircraft. It is unclear if HSCT will play a role in the future. A global, integrated air traffic management system will be necessary. Automation will play a role both in the air and on the ground. A viable short-haul system will be incorporated. Accident analysis and prevention will be emphasized. Cost reduction will be essential.

Trends in aviation will include:

- NASA working closely with the NTSB to try to make the NTSB a more proactive, rather than a reactive actor. NASA can help both in the investigation of accidents and in the simulation of accidents.

- Air traffic management will develop a new, integrated approach because this is necessary.

Tilt rotor research may be important for short-haul transportation.

NASA's role will be in the technology development process. NASA will serve as the risk taker for industry by performing basic research, applied research, and focused technology development. It will co-lead with industry in technology validation with a focus on piloted simulations and in-flight validation using the unique NASA facilities. Industry will lead in technology application and product design, development, and production.

NASA products must be relevant to, and directly usable by, the customer. We cannot simply produce papers and reports, but rather, should provide technical reports accompanied by software that can be readily implemented by the industry design engineer.

We must complement and supplement efforts of DoD, FAA, NTSB, industry, and academia.

Currently, industry has no true IR&D programs; all industry R&D is in direct support of a product line. Its engineers do not attend technical conferences nor have the time to read technical reports. NASA can compensate for this short-term focus by taking the longer view in planning its programs and by developing usable tools and techniques which the industry will not develop because of the economic risk.

NASA should serve as a role model for industry by establishing multidisciplinary approaches to technology development. This poses a technical and organizational problem.

NASA must capitalize on its unique "from computation through flight" expertise and research facility capability. It cannot simply be a clearing-house for external funding. Nor can it simply serve as the R&D laboratory for the U.S. aerospace industry. NASA must truly "add value" to the end product through joint participation in programs with industry.

NASA should have a role as a bridge between academia, industry, regulators, operators, civilian, and military aspects of the industry. This role is frequently under-appreciated. NASA can serve as a neutral party and facilitate a dialog and information transfer.

More aeronautics presence in local decisions
    i.e. From here to DIA to IAD to downtown DC Holdups?
    Because more people are flying
More urbanization
    Mixed mode transportation
        Rail TiltRotor HSCT
Population pressure
    Eg. Everyone will want a small refrigerator and small microwave

In the future there will be an increase in competition from the European block. Europe is interested in air breathing access to space and are currently investing in facilities to simulate the propulsion and heating necessary to operate at high mach numbers. The French have been exploiting the Russian facilities, this is a major threat to US industry world leadership.
The military will have an on demand global presence by using hypersonic vehicle to deliver weapons any where in the world within hours. NASA and the Air Force will have to take the lead to put the facilities in place so industry could build such an aircraft.
Since the big wind tunnel facility is not going to be built, very concerned that Europe will build facilities to improve their competitiveness.
Information technologies and integrated systems that will allow engineers to view how all the parts of the aircraft will fit together before actual construction, model aircraft dynamics via computational fluid dynamics (CFD), and create an aircraft database. This will allow for quicker decision making and time to market.
There will be a much higher reliance on high fidelity tools to begin the design process, not only by industry but by government to assure product potential.
Nano Technologies: These are technologies that go down to the molecular level to control atoms, these could be used for electrical components or smart materials.

The tough thing about this question is looking back 25 years and seeing how stagnant the industry has been. The next 25 years will break with stagnation and get supersonic commercial transport into place. We are now putting in 2nd and 3rd generation technologies which are fast, quiet, and environmentally friendly too.

We supply technology successfully and are being accused of corporate welfare for supersonics in the future, much the same as it is now for AST.

We will not be pursuing antimatter propulsion, gyrocopters, or personal transport aircraft. However, we may be pursuing more efficient means of bulk transportation.

Commercial pressures will be the same.

The number of flights are going up and will continue to do so. We now have a low accident rate. However, the number of accidents will go up as the frequency of travel does. The biggest breakthrough would be for NASA to bring information systems and air space operations on line to help with these safety aspects. We need a system to drive accident rates down. What that is, he does not know, but he feels it will be a big factor.

If supersonics do not go, it will be information systems and air space operations policy that is important to the industry. This is NASA's hope if it is applied by the government because there is no one industry that will be willing to do it. This is NASA's one hope if it cannot get supersonics to work.

In the next 25 years the aeronautics industry will be global. It will be difficult to separate national firms. The prime contractor and supporting contractor roles will be multinational. A firm may be labeled a U.S. company only because its board of directors meets in the U.S. Much of the actual manufacturing may be outsourced.

NATO's customer base may very likely not be U.S. owned firms. What is good for Boeing may not be good for the U.S. because Boeing may not use American workers for most of its production or, through alliances, Boeing may not be totally U.S. owned. We will see more trade deals based upon potential markets. Consequently, manufacturers will likely be compelled to consider offset strategies more extensively than presently.

In the future, commercial transport market economic factors will be more important than technological factors; that is, the cost of operations will be more important than technical capabilities.

Twenty-five years from now a weakness I am concerned about is the loss of expertise in the aeronautics industry. Twenty-five years ago a designer worked on 5 or more aircraft designs in his career. Twenty-five years from now it may be none.

In the future an important manufacturing technology will be an ability to create cost effective designer aircraft rather than larger production blocs.

In 2015, the greatest competitive threats will come from Europe and Japan: Rolls Royce in Europe, and Japan Inc. Japan is already investing ½ billion in hyper programs. Perhaps further along, China could be a treat.

Airbus changed their charter to include high-speed airplane research.

Technological issue—aerospace is a system business, not a technological business per se. Technology drives aerospace—it evolves decade to decade. NASA aeronautics and aerospace department—fossilization of what drove aeronautics.

- What drives design of new aeronautical system is information, energy storage, operational costs, functionality.
- Competitors have developed ways to absorb technology which makes their products continually competitive → outsource etc. → NASA can't do that because of civil service.
- Tension: how to keep system business vibrant when NASA not evolving.
- Technologies:
    - no technology to impact aeronautics business in next 10-15 years which we don't already know about. Ex: jet engines meet micro chips is current R&D.
    - energy storage device
    - bio-engineering devices—[his dream is to grow a functional airplane].
    - micro-miniaturization
    - information phenomenon
    - build machine intelligence into otherwise inanimate things (SMART structures)
- Theme: Once there is an advance in science, it is usually followed by an advance in engineering 10-15 years later.

Jet engines will be better, planes will be bigger, cockpits will be smarter, there will be invention which will change significantly the industry—big changes will come from outside the aeronautics industry—bio-engineering and micro-chips

- NASA is not going to create anything to prevent paradigm shifts.

Communications industry will have a huge impact on what flies and why. Business flight will diminish; pleasure flight will increase. Airline business will become more of a commodity. Cargo air freight will be major mover of high cost materials. Emphasis will be on just-in-time manufacturing. Manufacturers will have STOL airports next to their facilities. Cargo aircraft will be large highly maneuverable aircraft accessible to short runways. General aviation aircraft will be easy to fly as a car and cost about the same as a car. The emphasis will be on more smaller personal aircraft. Military aircraft emphasis will be on advanced weaponry. Military and civil air freight will essentially have the same airframes. There will be joint military and civil air freight partnership in developing technology. There will be uninhabited aircraft with a shorter useful life, of say 100 hours, for use as cheap fighter aircraft which are disposable. Civil/military extensions on information technology will be in the form of robotic operations.

Looking out twenty-five years, a development that I think will have a profound impact on the aeronautics industry is the tremendous growth in leisure travel. This will create a major traffic control problem. Not far into the future we are going to run into an air traffic wall. We will have a traffic jam of incredible proportions.

Noise and emissions will also structure the industry over the next twenty-five years. Increased fuel costs will be a big problem.

Information technology will be very important for dealing with congestion in the next 25 years.

Air shipping will increase dramatically. the demand will be there. The major constraint to large growth in our shipping may be acquisition cost.

The INTERNET may undermine domestic business travel. However, leisure travel and the Asian market will compensate easily. World wide demand for aircraft will outpace the ability of manufactures to produce. Look at the North East corridor. It is expected to grow 5% a year. Think what that will mean in terms of aircraft orders over 25 years.

The demand for air travel from leisure travelers combined with air traffic congestion will require more research in creating large airplanes. Perhaps planes with 1,000 person capacity will be required.

It is likely there will be fewer manufacturers but it is hard to extrapolate. You cannot discount national factors. Some nations may protect their industries even though they are not competitive in a free market. However, I think there will be fewer competitors.

Increasingly into the future there is an industry manufacturing a commodity.

The air traffic control system of the nations of the world will have to be standardized.

View in 25 years: a supersonic transport will fly the Pacific because the market will demand it.
A big unknown is the impact of computers and information technology. Conventional wisdom says computers and IT will reduce the need for air travel, especially for business travel. But, it could go the other way. IT advances may propel business travel because executives will have the capability to communicate with the office back home while on the road.
Among (and within) government things 25 years out will probably be no less contentious than today. Its unclear how government decision making will work. The nature of people won't change, and special interests will remain strong. The information age will make virtually all information available to anyone. We're not doing much to enable people to cope with that information and use it wisely today.
On the military side, unmanned aircraft are likely - not just drones but a broad range of aircraft.

The Persian Gulf War represents the future of war. The relevant technologies of unmanned aircraft may not necessarily transfer to civil aircraft, however - the costs to replace the person may not be worth the incremental benefit.

The industry has a focus of 6 months to 2 years out. Three years is a long time for them—so difficult to answer the question.

Fundamentals/Drivers: the job of the industry is to move people by air. What drives the industry is the ability to do it faster, more efficiently and safer.

- Have to ask what's involved in moving people faster and safer:
    - can't do more with subsonic airplanes
    - hyper sonic on the horizon, but its not economically feasible.
    - airframe aerodynamics—not too many changes, although perhaps important changes in materials.
    - propulsion?
    - computational?
    - handling flow of traffic?

Developing countries will have major networks, although no road networks. Because of their dense population they will want good transportation, but will not want the troubles of congestion which comes with roads and cars.

He can see short and long haul air travel.

City to city air transport as a means of developing undeveloped pats of a country.

Technology issues:

ATC, navigation, anti-pollution technology needs to be sophisticated because there will be more planes with increased short-haul traffic. More vertical take off and landing anticipated. The size of the aircraft: 50 passengers for a short haul plane (bus with wings)

Technical issues which affect operations:

- Micro-electronics which are used for the automation system in plane operation. **Problem arises when humans can't interact and properly operate automated systems. Many accident of date are caused because of poor human interaction with the technology. Human factors and cognitive engineering will be reflected in the training of pilots.
- Is there a problem of the "unidentifiable bug" because the systems are becoming more complex? Yes, and its going to get worse.
- Electronic terrorism: the military is worried about electronic pulse regarding nuclear weapons; and the airlines are worried about information warfare—the ability of evil people to intercept signals, change them, and cause trouble—"Hacker" terrorists.

1. High Speed plane is flying - Mach 2.4
2. Environmental concerns
    Global warming-More travel by Pacific rim
3. Flying wing transport more efficient
4. New transportation breakthrough
    Mag-Lev Train or equivalent

(Aside: NASA should be working with the FAA for a more efficient ATC system)

5. Pacific rim is the driver
    China growing 10-12%
    Might push development of High Speed transport
6. Europe and Africa are not a factor

When reflecting upon the future of the aeronautics market, one can look to the automobile industry to provide a frame of reference.

A low cost alternative to low cost subsonic travel does not appear to be promising.

The capacity of the system must be increased.

A demand for High Speed Civilian Travel will be prevalent in some markets, however it will be limited to specific regions.

In order to hold the interest of travelers in air travel, the accident rate must be reduced.

There will be fewer manufacturers of airframes and engines in the future. It will be harder to keep a distinction because there is too much similarity between the problems facing each.

There will be few turbine engine companies: a couple of large firms, but mostly small ones.

There will be a greater degree of concentration. This may help the government/industry relationship because we will not be supporting development in two or more different firms.

The number of passenger miles flown is still going up. This may continue along with a drive to "get there quicker."

Telecommunications will drive down business travel. Things such as video conferencing will prevail due to the fact that they save time.

The thought processes about business travel are changing. Personal travel may increase as the business travel decreases.

Simulations (numerical and other) and predictions generated by computers may change the market and significantly effect NASA. Its testing facilities are why NASA is important for Aeronautics. The industry cannot afford to build the wind tunnels and other test facilities so they turn to NASA for these services. As simulations become more common in Aeronautics, they may detrimentally effect the role of NASA facilities.

We will do things differently in 20 years because of computers and communications technologies.

Two scenarios would be interesting to consider: 1) business class travel changes due to technology (with limited effect on international travel) and 2) communications futures 5-10 years from now.

A lot of manufacturing will go overseas. Boeing will become basically a systems integrator of a lot of foreign subcontractors. Offset demands on Boeing and its willingness to use offsets as a marketing instrument will encourage overseas production of much of the airframe. Production will especially go overseas if aircraft production is thought of as a commodity. Only if advanced technology is featured in U.S. aircraft will production remain in the U.S.

In the military sector there will be greater emphasis on UAVs. These units will have low prices. It is likely that smaller firms can thrive in this market.

Some other relevant trends over the next 25 years include: (1) greater compactness and capacity of computers; (2) significant advances in micro electro mechanical systems (MEMS) which will have tremendous potential to change aeronautics.

The INTERNET and other communications innovations will mean that people will spread out more in their work. This could very well lead to expanded markets in general aviation. NASA needs to look at safety issues in general aviation. We need to help develop automatic systems which are friendly to pilots but help reduce pilot error.

Boeing, Airbus, and some sort of Japanese Airbus will be the three dominant players. I do not know if this triumvirate world would be a positive or negative development.

U.S. Government will be doing Aeronautics. Maybe through NASA, maybe not. I do not think that the Air Force and NASA will continue to coexist.

View in 25 years: a supersonic transport will fly the Pacific because the market will demand it.
A big unknown is the impact of computers and information technology. Conventional wisdom says computers and IT will reduce the need for air travel, especially for business travel. But, it could go the other way. IT advances may propel business travel because executives will have the capability to communicate with the office back home while on the road.
Among (and within) government things 25 years out will probably be no less contentious than today. It's unclear how government decision making will work. The nature of people won't change, and special interests will remain strong. The information age will make virtually all information available to anyone. We're not doing much to enable people to cope with that information and use it wisely today.
On the military side, unmanned aircraft are likely - not just drones but a broad range of aircraft. The Persian Gulf War represents the future of war. The relevant technologies of unmanned aircraft may not necessarily transfer to civil aircraft, however - the costs to replace the person may not be worth the incremental benefit.

In the future the industry will be downsized with fewer firms. There will be more international collaborative and combined efforts. HSCT is an example where, due to high costs, a consortium may enter the development competition and change the game.
No firm can afford to build a "Son of Concorde" with only 16 planes. That is why NASA will be critical. HSCT will be a technology driven airplane in which all technologies have been developed and proven before incorporation. HSCT may be ready during the timeframe of the study but this depends on whether the market and technologies are there or not. If there is no market, the industry will not push to finish the program.
Lots of technologies will impact air transport systems including GPS, free flight, etc.
We will see different business arrangements such as lifetime service for systems included in the purchase price.
There will be some infrastructural changes that are transparent to the public.
Air transport will continue to grow in spite of communications technology developments. No telecommunications technology can replace face to face meetings.
Prices will be stable with more people traveling, especially along the Pacific Rim. More people will travel as the time for flight decreases. For instance, if the flight from Japan to Los Angeles was only 2 hours and was affordable, then it becomes more feasible to weekend in LA for the Japanese.
One key concern is about the environment. We need better solutions for environmental issues or growth will be inhibited by economics. This is an opportunity for NASA.
NASA's mission will be to reduce cost, meet technology needs, and find ways to build things better using simulations and process modeling, all while maintaining safety.
Better NDT is needed for improved safety.

Manufacturing technologies could be a new area of emphasis for NASA that would provide pay offs. Currently, this type of technology is not invested in heavily enough.
NASA continues to work hard on some areas that are no longer paying off simply because they have traditionally worked with them. NASA needs a new investment strategy approach with more involvement in the industry and better pay offs.
We can no longer afford to develop "neat" technologies with no understood applications. We need smarter investment strategies. This is already causing stress between the industry and NASA. It is necessary to shift priorities from pure research to real research. Without customer support, NASA will not survive. We must understand their needs and serve the customer or go out of business.
Industry should provide lobbying support to help NASA aeronautics. For instance, explaining to Congress that for every dollar spent by NASA, GE and Pratt are earning X tens of dollars. (The GE 90 for the 777 has NASA's E^3 program's compressor and this will make a big impact on its costs and profits.)
NASA needs more feedback on what the industry's needs are so that there is no duplicated effort or useless technology.
In 2020 NASA will be downsized considerably, the centers will be interdependent (facilitated by modern infotech and budget pressures), and there will be a blend of Aero and Space with each reserving some niche roles.
Commercial research focus will boost supersonics and the research will provide improvements.
More work on hypersonics will be conducted.
Access to space will be emphasized.
Air breathing engines will work with Space technologies.

Significant increase in global population
Leveling of per-capita income across regions and a redistribution of world wealth
Greater proportion of people traveling will be Asian
Greater proportion of people traveling will be non-business
More specialty aircraft (private through cargo)
More exotic materials is use
More auto-control
New and different configurations for some passenger planes
Substitutes for business travel
Time poverty (my term) and emergence of time as a resource
New uses of time in flight and higher sensitivity to time lost in travel
In the military, fewer manned flights for some missions
Barring severe conflict, an internationalization of aircraft mfg.
Major players will be: US, China, Eur, Russia, England, Japan
New ATC system
Airline consolidations, mergers, consortia
Greater role in Russia, EE, and ME for the US
SE Asia involved in small plane mfg.

I think the following will occur: The aeronautics industry will continue to grow; there will be an even greater demand for air cargo; telecommunications will not reduce passenger travel; personal travel will increase, particularly the demand for foreign travel; telecommunications may actually lead to increased travel as it enhances interest in foreign travel.

I am less confident about this but I think personal flight vehicles will have a large market by 2020. All we need is miniaturized power sources. These systems will be mostly controlled by air traffic controllers. Alternative energy sources could also bring about such vehicles if the energy is light, affordable and dependable.

Increasing competition between global suppliers

Europe vs U.S. vs Asia Pacific (suppliers only)
More positive scenario (wishful thinking)would be for U.S. companies becoming international
Airlines will also become more global (consortia)
Military will be dominated by U.S. companies
Supersonic business aircraft - not Boeing but more probably a military oriented mfr.

In 25 years from now the re will be a
- New conventional subsonic transport Mach .84
  - 85% of the market
- New High Speed transport Mach 2.4
  - 15% of the market
- New process for technology
  - Get A/C to market quicker
  - Build pieces
- Double the price of fuel(Fuel good for 40 years)

Can the company make profits? "Bet the company" to develop new product, and return on investment starts 10-15 years later.
Consolidation—large industrial complexes, but they still need to make money. The aeronautics industry is starting to look like the oil industry regarding large conglomerates and long amortization of costs.
International partnerships: perhaps with the Russians. The Japanese are currently buying Russian expertise, not Russian companies.
Where's NASA in a world of international ventures? The role of NASA is to transition its R&D, not to transfer it to foreigners.
Europeans saw the need for new wind tunnels 10 or 15 years ago.

Technology changing? If technology was only left to industry it would take short steps. Government labs are necessary for technological development, then transfer to industry.

Customer ideas works both ways: need to be aware of conversion costs of technology to product.

Problem in understanding between government and industry—improvement in the future because of economics.

From a global point of view the technical and economic strengths of today will drive the future..
- Russia will be a player
- Japan will pick up
- Europe leveling out (Airbus wanted 1\2 of market-got 1\3 now and that might be all)

The traveling public will be more recreational; business travel will stabilize at a modest level; home based web-oriented information technology will be the norm. The civilian recreation traveler is interested in safety and economy. The business traveler is interested in efficiency without delays.

The world airline fleet has essentially been equipped with hush kits or will be by the year 2000 but the various environmental groups are pushing for even lower noise and lower emissions.

What is really needed is more human factors research to drive down the accident rate. The rate is stable but traffic is increasing and 80% of causes of accidents are human related.
*The above future comments are related to the subsonic regime.

As far as the supersonic field it is felt that payoff will be in the over ocean areas especially the Pacific rim. The combination of:
- Logistic changes by the airlines

One day business trips anywhere and
Mach # for twice a day flights (only 25% more than today)
will be the norm in 20 years.

The hypersonic access to space is still considered visionary.

In answer as to what might derail this vision of the future, the following was offered:

- Trends to restrict growth
  - Environmentalism pushing technology
- Major changes in world order
  - Military affect-Civilian reaction
- Economic growth
  - Stagnation-recession
- Tilt rotor
  - Rapid rail
- Capacity and efficiency of present ATC system
  - Free Flight

Military: Do not have enough knowledge to comment.
Civil: Quieter and more fuel efficient aircraft with more efficient systems such as free flight and reduced taxi times.
In 25 years we will be starting a new generation of aircraft to leap frog SST technology, this will be closer to a space plane.
Environment issues are going to kill a SST in its current form.
Boeing and McDonnell Douglas civil transports will combine to confront Airbus and other competitors.
Airlines will be the same as they are today.

The small aircraft fleet will be completely new. Today the average age of and aircraft is 30 years old, in the future the aircraft will be newer exploiting the advances in propulsion, aerodynamics and avionics. There will be an order of magnitude increase in personal use.
Commercial aviation is independent of GA. There will be larger aircraft in the future, free flight will become a reality, more planes in the air, more discount airlines, and less confort in flying.
GA growth will come out of trips that are not currently made because they are too far to comfortly drive but too short for taking a major airline.
Administer Goldin vision of GA has a high probility of coming true if we make the right decisions now.
A Growth in the small aircraft industry from 0.01% of the population flying to 10% of the population.

Years from now - airplanes are being developed now which will be in the fleet 25 years from now - airplanes fly-by-wire looking much the same as today.

More connection between American and foreign airlines e.g. NW and KLM, American and BA.

More safety regulation.

More emphasis on of airline safety.

Safety will impact costs.

Super Sonic - Sonic Booms environment concerns, unless resolved, will impact supersonic travel. It will also need to be cost competitive.

There will be global navigation and control system for aircraft completely based on satellite technology.
There will be a mix airline fleet of both subsonic aircraft for domestic routes and supersonic aircraft for intercontinental flights. The airline market will continue to grow.
The supersonic transports will be built by an international consortia.
General Aviation will look similar to what it looks like today except they will have satellite air traffic control information in the cockpit and they will be safer to fly because of this new information. They will still be prop driven and used primarily for short range. There will be more business jets as more and more companies build their own air fleets.
The first operational combination of air breathing and rocket powered access to space will exist.
Integrated information services will dominate; traffic, weather, optimization of flight path will be fed into the cockpit. This will be a system beyond free flight.
However these aircraft will not be fully automated, there will always be a pilot.

Acquisitions (2 or 3 large companies - more global alliances - high speed commercial transports and supersonic bus jets, super large (maybe amphibious) cargo carriers.

- Subsonic airborne buses - new ways to move people to airports.
High speed travel
Outsized cargo
People movers
Aeronautical principles for access to space.
Hypersonics new thrust for military

More unmanned vehicles.

From a global point of view the technical and economic strengths of today will drive the future..
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Japan will pick up
Europe leveling out (Airbus wanted 1\2 of market-got 1\3 now and that might be all)
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Virtual companies will emerge as the norm
Global economy - centers of excellence - driven by economics
Different sets of companies to produce different products/designs

"IT is the stuff that brings it all together"
Long Haul - NASP
Short haul - small variants for improved performance
Free-flight will favor unique aircraft design (tilt rotor, etc.) new air transportation market may emerge (downtown to downtown)
AGATE outputs (design plus procedural capability) will change short haul market response to demand.

Products will be cheaper because of advanced technology (materials mentioned).
- Automated fuselage building.
- Better engines
- Tiltrotor will provide faster and more people carrying capability.

EU is expanding Airbus—Airbus consortium is growing as a competitor.

If Russia gets its act together, it will have a large internal market. Because of FAA requirements, Russia can't market outside of the Eastern bloc. But once that is remedied, Russia will be a significant competitor. .JV's are already going on—Pratt & Witney is already selling certified engines to the Russians.

What if the US companies team up with the Russians? Will have a problem/conflict over NASA's role. What if Russo-Airbus alliance? Will be a formidable competitor / challenge to Boeing.

**Can't suppress the flow of technology. The way to maintain market advantage is to increase R&D for the next generation.

We created the Airbus monsters when we exported the C-FM-76 engine to the Europeans in the 1970s. Airbus got its engine technology from us—we were too shortsighted at the time to see that such a decision would come back to haunt us.

Military technology: a continued slow down in military development (that's why they want NASA's help). It will a long time before a new tactical fighter plane will be developed unless a new enemy emerges. The tempo has slowed and will continue to slow on advanced tactical transport to complement stealthy fighters.

May see small deck aircraft carriers. If this succeeds, will need support planes to operate from small carriers.

Global reach aircraft—12,000 mile range capability to go anywhere when need arises.

Air breathing launch vehicles. Capabilities for hypersonics has been around for 30 years. The technology is not the issue, but a sustainable mission is. Use for such an aircraft is the issue, because have to determine whether its worth making the capital investment and taking the risk. We have an engine where thrust is greater than drive, but can't build it because its not economically feasible. He doesn't think there is a market to sustain a hypersonic plane.

NASA's supersonic effort is focused on Mach 2-2.5. The suspicion is tat a super cruise engine cycle for the F-22 might lead to a viable Mach 1 or 1.5 supersonic plane, a poor man's Oriental Express. But the economics still don't quite mesh to make a mach 1.5 viable.

All it takes is a 20% speed advantage to knock the competition out! Mach 1.5 is a significant speed advantage to make a difference. However, it raises environmental, noise, sonic boom issues over land. It might be feasible if transoceanic travel demands it.

Additional downsizing in the industry, based on fewer projects.

Laborforce?
The industry has trouble attracting young qualified people, especially in electronic, avionics, software side. Young grads are going into the commercial sector instead of military or aeronautics, and now doing what's not related to aeronautics. Salary pressures are a contributing force—get paid more in the commercial sector.

Not the same disparity in manufacturing.

Global aero 25 years hence - HSCT airbus will dictate - Government needs to play a role in integration and implementation of this technology.
- Keeping old airplanes safely flying because of longer lives is critical.
- Future needs. Accuracy of weather prediction, freight, perishable cargo, unmanned applications, new airplanes for moving freight. Smoke and fire detection (transporting animals.)

HSCT will happen.

Larger subsonics will meet the demand generated in the Pacific Rim. This means bigger engines.

Engines that are self-compensating for errors and stay on wings for the life of the aircraft will emerge.

Engines will be quiet, clean, flexible, and integrated with the aircraft.

Peripheral systems for engines will disappear.

Oilless engines will emerge.

There will be lots of consolidation; there will be bigger, fewer players that will partner on large projects; and there will be less head-to-head competition.

GE and Pratt will build the 747 replacement and growth market engine together.

There will be a greater degree of global polarization. There will be more global competition, but less within the U.S.

Financing will change. Firms will sell a guaranteed transportation package. "Power by the hour" will be common. If the product breaks, you do not pay for it. Airlines may buy services rather than the aircraft and engine itself through leasing.

Outsourcing of maintenance will be common. Specialized maintenance firms will support those that actually own the products. Airlines will broker services to the public without actually owning a product line.

Pilots may contract out to various airlines. Airlines will determine what they have to own and employ and what they can contract out.

We may have free flight which will lead to a very different air traffic control system. The hub/spoke system would no longer be necessary. We may see civil tilt rotor service in the new system, but this is unlikely.

There will be a resurgence of general aviation. New technologies will be needed to increase safety for GA. Greater all-weather capabilities will emerge. Systems will be more autonomous with new technologies such as GPS.

Whether there will be a government partnership or not is questionable. We still need support for R&D, in fact it is more important today because the money is not there. Industry may outsource R&D to the government as well as manufacturing and fabrication/design. Industry will be systems brokers, not "piece/parts doers."

Respondent was asked how NASA Aeronautics will change.
It will be smaller with fewer people.
There will still be close cooperation between NASA and industry.
Universities will become more effective partners with NASA.
NASA will engage in more partnering in general.
NASA will play a larger role in transitioning of technologies into applications.
NASA's customer base will be broader with greater interaction with the automotive, electronics, information management, medical, and machining industries.
NASA may start to receive income from spin-off products to pay for development: some sort of recoupment fee.

NASA will become more business-like in its management as well as more effective and efficient. This is not necessarily at the expense of long-term research; research will just be better planned and there will be a shorter time period for technologies to reach fruition.

NASA will have more directed research and more multidisciplinary research taking place.

There will be an exchange of personnel. Hybrid people that move among organizations or between Centers. These people will have benefits, etc. but they will move between jobs. They will be employed by the industry but may move freely between industry, NASA, government, etc.

What will motivate going forward.
- Answer - $
- Need tax credit, etc. to companies to invest more into longer term research, experimental aircraft or simulations.
- less flight testing, less wind tunnel, go to networks of simulators - etc. now come to pass attend industry change to explore more concepts even more than when had lots of experimental aircraft.
- Look @ 777 - video teleconferencing to compare notes - major step forward compared to 5 years ago
- Needs to become profitable to look further at impacts.
Need follow-up qualified suppliers, assured process.
IPPD - leverage current industry tech rev
Info system real time - what ifs, collapse cycle time.
Advanced distributed simulation tech
- Distributed company - changes made rapidly - robust simulation and modelling.

IPPD Helps get up S curve but doesnet get you to the next “S” curve.
Who’s going to do next concept
- in past - government and industry
- today - industry and academia
- remains to see if can transition anything - initial honeymoon stage
- issue how to take to market
- culture in academia - different than business
- old way - worked together, lump into product, get out
- every year - want to take out of 6.1/6.2 to support OPTEMPO/TRN etc.

Global aeronautics 20 years - High speed airplanes; multi-national teams on high speed: climatology, environmental emphasis using UAVs.
- VTOL will grow in the next 20 years for short hops.

Future will look like the present, except for high speed

- Military support will increase again cyclic in nature
- Technological access has increased causing leveling of other countries
- Supersonic transports will be in service
- Dryden could be involved in near space activities
- High altitude sensors
- Russia and China will become major players in the market places and the aeronautics game.
- New aircraft will maybe not happen.
- Personal aviation market should explode in 25 years because of NASA R&D.

commercial market largest
military - hypersonic air vehicles
civil supersonic transport - supersonics will replace long range flights 2010 HSCT in service.
More global alliances - aircraft and electronics in civil aviation
Derail this above scenario - a new evil empire.

Civil industry will be more global., Routine supersonic civil transport flights. Military will be hypersonic to some degree. Reusable launch vehicles will be available. More merging/integration of technology.

It will be a world of global partnerships. There will probabaly be two big manufacturers 1 US-Boeing,MACDAC,etal I Foreign based Euro-Asia plus a number of niche players.
The military will emphasize quality rather than quantity and there will be more unmanned aircraft and more emphasis on regional conflicts. Military will still be funding Higher, faster, and longer range while the commercial side will focus on subsonic and supersonic over water.

Military industry will have 2 companies; Lockheed and McDonnell-Douglas
Civil industry will have 3 Companies; l American, 1 Euro, 1 Asian
These indutries will probbably be large “integrators”
NASA Aeronautics should grow
Companies will not have R&D assets eg wind tunnels
Limited developments
Need national strategy

25 years - commercial airplane shape will be dramatically modified - computer will make shape fly.

It will continue to shrink, because of budget crunch in US and Europe. More competitive as to markets; cost conscious future, need to focus on low cost; life cycle cost; high barriers to entry.

What’s the core competency / capability of the aeronautics industry.

- design core—know-how—people—engineers
- manufacturing –ability to build

Industry will not be able to maintain its core-design, to help maintain it, is must continue to build prototype, if we don’t put a team to build the hardware we will lose that capability. Companies will not put resources into designing prototypes for no market, because they think it is a NASA

and DOD Function. Government has to step up to the plate unless wither away the industrial base. Future where NASA and DOD blend/closer together.

Need to maintain a manufacturing base, industry outsourcing more and more, becoming assemblers, like the industry.

International business is the lifeblood of maintaining the manufacturing base.

Basic R&D problem is inflated because industry is not going to do it → national problem. --

Looks at the future in terms of probabilities:
60%- A whole new era, GA aircraft are an order of magnitude easier to fly, cheaper, less regulation. There will be 1 million pilots versus 600 thousand today, an active fleet of 220-210 thousand GA aircraft versus 160 thousand today. The business jet fleet will double in size with a lot of growth outside the US. GPS and FANS will help spur this growth outside the US.
40%- Basic stagnation of GA aircraft. There will be same number of pilots and aircraft with the industry supplying replacement aircraft for the aging fleet. The cause of this stagnation is no new regulations to lower instrument rating time for new pilots.

Driver will be t ravel time. The demand for faster and most efficient are transportation will be major factor . Cost and comfort somewhat of lesser importance.

China will enter as a major market, incorporation of Hong Kong will help. Vietnam and Malaysia will also be growing markets for new aircraft sales and flight routes.
Western Europe will stay about the same size but Eastern Europe will be another growth area.
Increasing world population will cause a need for more air transport.
The driver in the future will be cost, safety, performance (but not as big as cost), and environmental impact. There will be more big aircraft, not faster. Airlines are looking for aircraft with even cheap passenger per mile rates. There will be an increase demand on the air traffic system, GPS will have a major impact on the new systems (free flight). Auto landing systems will be incorporated to avoid weather delays and improve safety.

Highly dependent on industry structure, but there will be a small number of players that will develop a family of aircraft and propulsion systems. Countries could shape the future like the asians could leverage a 100 passenger aircraft into a stronger position.

Unless there is an ubforeseen super break through in technology ythere will be no major changes, only incremental changes with some electronics evolution. There might be a new joint strike fighter, helicopters have reached a plateau, and civil tilt rotor will not be economically feasible.

Hope the industry will figure out how to break the bonds of the atmosphere, i.e. single stage to orbit (NASP).
Military will be concentrating on affordable weapon systems instead of bigger sexier platforms.
Safety record might have a major effect on public acceptance of air travel.

There will be more partnerships on a global scale, driven by the cost of doing business / research.
There will be a harmonization of regulations, NASA report on fatigue has already been used by JAA and the FAA in new regulations. ICAO is too bureaucratic and slow. In the future decisions will have to be made quicker to prevent countries from side stepping ICAO.
Free flight is a collection of programs currently underway and if it going to make it these programs need a kick in the pants and need to get out into the field. NASA will have a role in free flight cockpit display and the human factors associated with it. We will be linked to Europe, decisions we make will effect them, and vice versa.

Consolidation and Consortiums will be the norm. There will be two American Hleicopter companies and Sikorsky will be one. Lockheed and Boeing the two fixed wing companies. Europe will have one aircraft company Aerospatial, and one engine company SNECA and one helicopter company Augusta. (Eorope could combine and become a state) Israel will not be able to compete in a world market, military specialities only. India will have an aerospace giant company. Japan will start producing aircraft. Japna will produce the first HSCT, probbly in partnersip with US. Brazil will have 2 aircraft companies and there will be atleast one more in South America. Indonesia will market a 150 passenger aircraft. Russia will recover and become a major aircraft producer. Russia will also be a big helicopter user. China will develop an enormous capability, first with US and then on it's own.

There will be no more commuter aircraft produced in the US. General aviation will still be choked and a small helicopter will not be developed because of "lawyers". The US will still be the worl leader in large aircraft and helicopters but other aviation aspect will go off shore or become multinational. A civil tilt rotor will finally be produced.

In 25 years there will be a severe lack of people will aeronautical specialies especially engineers. Women and minorities are not attracted to this field of work.

What are the principal trends under way that will stimulate the changes you envision?

World economic changes, balancing of wealth (developing countries rising), people's desire to travel, telecommunications will not replace travel, recreation will drive airlines, air cargo.

More international competitiveness, no clear results.
Growth in world economy; i.e. increased number of planes and passengers.

There will always be a need for face to face meetings.

Gross Domestic Products will continue to cyclical
Relative Pricing will prevail

Threat is a driver for technology, we have been the leader in technology in the past and we must face the new threat from foreign corporations.
NASA has to start taking some risk to advance technologies, such as Nano technology.

We need major breakthroughs in safety. This may be achieved by removing pilots from controlling aircraft in flight. Position and health of the aircraft must be continuously monitored remotely. This requires more structural and electronics health sensor monitoring, and a need for improved maintenance. Need redistribution of work done on ground [ATC and remote piloting/monitoring] and in the air, that is, automated autonomy in the aircraft. We need free flight.

A major trend driving things now is the increase in disposable income in the global population, because its used for travel and tourism. Business travelers become 1/3 of passengers.
More air travelers than now and most of the growth overseas →market for aircraft overseas.
The challenge for the future is a global AT system
Ex: air traffic management system—tracks all planes flying across US
ideal world –one global AT system—integrated system. Ex: across the world will know what's coming in 4-5 hours. (May be undermined by terrorism)

More competition—suppliers –but will undercut goals for a global system because of tensions between global v. nationalism
Other countries will be caught up to US technology. US will not be the leader in many areas → issue of a level playing field—how to handle that new field.
Question of industrial policy—loss of national leverage—US becomes 15-20% of air travelers in year 2016
State of commercial carriers?—US v. Europe? Openness?
Openness to new entrants—4 or 5 major carriers—small carriers don't last. He doesn't see the world becoming more open because of *nationalism*. Desire for national airline all has to do with jobs.
Role of MNC v. national government → in the end nationalistic forces are more regional →international spheres of influence.

Big issues and trends that will plague the industry of the future will also include safety, acquisition cost of aircraft, fuel efficiency, and environmental pollution. Technologies that are being developed need to address these crucial issues.

In the U.S. the airframe manufacturers will buy out the engine companies. The engine is 25-30% of the business and the airframe firms will try to do the whole thing.

Countries will continue to protect their own employment. Offsets will lead to more sharing of the work. Ultimately, the countries will take over all of the work in stead of doing offsets in order to keep "quality jobs" in their country.

This industry is becoming globally competitive and this will not change in the next two decades. 15-20 years ago, we did not consider the Japanese as big competitors. This has changed today- we have a different set of competitors. The Europeans have advanced in emissions control and other environmental controls. In the next 15 years, partnering and consolidation will become a principal trend. Global partnering of products has already begun. For example, P&W has teamed up with GE in the area of high speed level transport. Technological partnering gives us access to new markets - the business motive will dominate most alliances.

GA will see a need for longer range aircraft, but there will always be a demand for the same ranges flown today.
There appears to a some need for a supersonic business jet, but this will be a very small market.
Tele conference does not limit travel, it will increase the need for personal face to face interaction and travel.
There will be a globalization of the corporate world.

5. What kinds of key events or situations could arise in the time frame (25 years) that you would consider plausible, yet could cause a major derailment or deflection in the evolution of the industry you described above?

Fuel crisis similar to 1973.
War
Disease.

War, loss of access to oil, environmental issues, such as noise and air pollutants.
In terms of the military it is hard to predict what will come in the future, except any technologies break throughs will have more effect then on the commercial market place.

Fuel, cost increases, global economic slowdown, environmental restriction (there are more airplanes coming on line then there are reductions in pollutant emissions).

The greatest risk is terrorism. When Lockerby happen there was a 50% drop in trans Atlantic bookings. If this same type of drop off were to happen to domestic flight some airlines would go out of business. Security is very labor intensive and if it is tighten any more this could swamp airports.

The buy American concept; having countries close off there markets to outside competition. This would also close off teaming with foreign partners, which would close the door on new foreign technologies finding there way onto US aircraft.

The current US budget, we could go bankrupt.
World stability: This includes an oil embargo or world conflict. Aircraft will have a very hard time switch to alternative fuels if oil was to run out.

Technical break throughs by a competitor, right now only the Europeans have the technical know-how for such a break through but the Asians are looming on the horizon and are a larger threat over the 25 year period.

Oil crisis, war, political upheaval (China, Russia, Africa), major US government reorganization, major labor strike (Boeing is at risk)

Unstable Middle East: military is once again very important, allowing for the evaluation of risky technologies. This however will have a long spool up time because of the reduction in long term risky technologies.
The reduction in the size and quality of the skilled work force.

Terrorism, the aging fleet, however there seems to be a pretty rosy future ahead for the aero industry.

Closed world- European airlines only buy European planes, American Airlines only buy American planes.
A major technology step forward not associated with the US industry.
Don't see video conferencing or internet type technologies slowing down the airline business.
War, hot or cold

A major war could derail development programs. Historically, major wars have reduced efforts to develop, especially for longer term projects.

The Europeans and Japanese are now having problems competing, but this could change in the future.

Terrorism
Health
- Human and crop
- Could be adversely affected
- Infectious diseases

Comment: Every transportation niche increase opens possibly more problems quicker.

Federal Deficit: We might not have the money necessary to invest in high payoff technologies.

Really good information technology that destroys the perceived need for business travel. This will have a really big impact. Significantly decreased business travel will destroy the base for industry pricing. This, in turn, means higher prices for leisure travel and a concomitant decrease in such travel.
The real breakthroughs in the past 20 years have been in ground transport.

Another detrimental event would be if Boeing moves stuff wholesale and political winds allow them to become a U.S. based firm operating in Indonesia. This would significantly effect the job base in this country.

Aeronautics is driven by a skill base and technical knowledge. It is unclear that the need for these skills will disappear.

Terrorism will effect some leisure travel, but business travel will continue in spite of terrorism. Terrorism will spread fear, but not change behavior.

The environment which drives the system:

- loss of competitive edge in manufacturing
    - aeronautical products don't evolve to the point that they're a commodity. If a fraction of the market lost, NASA's purpose which is to maintain the health of industry and the balance of payments, is undermined.
        - If aeronautics became a drain on the balance of payments it would undermine NASA's purpose, and leads to the classic Beltway reason for perpetuating NASA
- A foreign competitor jumps ahead of the US in technology and product development--**major successful technological risk from foreign competition
    - the risk is that it would be written off like the Concorde—but they should learn from Boeing in misjudging Airbus A300.

If a hot war or a cold war re-emerged, would it rejuvenate the industry?

- US doesn't have a lot of military planes
- US government concedes that it's going to lose 20-30% of market to Europeans.

Dramatic changes in national security of US, for example: a) China develops as rival in cold war; our major emphasis would be on military defense posture; b) Global warming perceived as a real threat; may result in a carbon tax on aviation fuel; may lead to need for significantly improved aircraft fuel efficiency; and c) Global economic depression.

In a positive sense, the direction of industry could be directed by a completely unpredicted event such as a new engine design or a new type of fuel. On the negative side, a major derailment could occur if we could not get adequate amounts of fuel or if fuel prices tripled. We could run into barriers slowly too. I have mentioned the airport capacity problem. Airport capacity may undermine growth.

Hard to imagine a single derailer - perhaps a form of societal breakdown? All indicators now are pointing in the right direction.
Terrorism could drive the industry towards different kinds of systems and even different aircraft, especially if there are serious terrorist disruptions (for example, that involve nuclear weapons).

Disposable income—if it decreases then it causes all sorts of consternation. If everything is booming →globalization; if income discrepancy too big → regionalism.

Hydrocarbon based fuels could affect the direction of the industry

What about terrorism? [this question had to be asked—he did not mention terrorism until now]

- big impact
- electronic terrorism in the plane
- Should be looking at counter terrorism mechanisms
    - Should it be a government or an industry role?
        - its a political and military issue
        - NASA is doing sensor and structure work which has potential to contribute to counter terrorism research.

If suddenly there is a real shortage of fuel, all goes to hell. A hydrogen economy is a dream, because its not good in energy per volume although good per pound because it's light.

The Economics of the industry will be changed by a downward shift in business travel? There is a limit to which people will agree to do things vicariously.

The supersonic jet, which would reduce the travel time from Japan to NY to 3 hours, would totally undermine the need for teleconferencing/video conferencing. So video conferencing will not have a big effect. [Editorial comment: But the viability of a supersonic jet depends on economic feasibility].

Political instability or an energy shortage. The Middle East could be the problem area. Also a major war.

Several areas can be anticipated to affect industry in the future. One of these events would be an oil embargo. Another is the discovery that we are severely harming the environment. For example, a variant of the hole in the ozone problem could affect the aeronautical industry. Other areas include the state of the world, or global conflict. Also, the accident rate of the industry will play a role in defining the future. Directly tied to the safety factor is whether or not we can effectively handle large volumes of aircraft.

There are four factors:

- The availability / cost of energy
- A negative change in the U.S. economy
- Not having a product for the "new market"
- Safety issues related to aging fleets

Regionalization will have a negative impact on the growth of the aeronautics industry. If three trade blocs, U.S. dominated, Europe dominated, and a Japan dominated, emerge there will be major stagnation in the aeronautics industry.

Actually, in some ways the aeronautics industry has been derailed. Throughout the 1970s and especially the 1980s aeronautics research was focused on military issues. This was often cutting edge research. But the decline in the demand for performance from the military means there is really no customer interested in cutting edge aeronautics research. The long term consequences may well be very limited advances in aeronautics technologies.

HSR may confront setbacks in terms of fuel availability and cost.

Hard to imagine a single derailer - perhaps a form of societal breakdown? All indicators now are pointing in the right direction.
Terrorism could drive the industry towards different kinds of systems and even different aircraft, especially if there are serious terrorist disruptions (for example, that involve nuclear weapons).

An oil embargo would shake up the industry, as we are heavy reliant on petroleum. The Middle East is a highly unstable region and this instability could effectively derail the industry. He briefly touched on alternate fuels including hydrogen and more exotic substances.
Environment restrictions could also impact the industry but there are practical limitations to how low one can go. Noise control, restricted altitude, restricted air space are other less potent forces.
The extent of terrorist activity could affect commercial aircraft and other high value type targets.

Industry has allowed itself to become more dependent on NASA. If NASA cannot or will not deliver, industry will review its own research capabilities and reinstitute them. Relations must not be allowed to unravel or NASA will lose its major customer.
If another major space disaster were to occur, the Agency may spin off Aero into some other entity (FAA or dod perhaps.) There is constant pressure to look at dod vs NASA. Two could go to one. Such a formation could be great or it could be a disaster, but the separation of aeronautics may be a threat.
If NASA rests on its laurels it could be threatened. NASA must market itself and demonstrate its usefulness and the return on the public investment in order to survive. In common terms, "why must we support aeronautics in NASA" is a question that NASA must address more carefully.

War
Near-war conflict
Global economic catastrophe
Health threat
Climate shift
National security / restrictions
Technology breakthrough
Air catastrophes
Shortage of capital
Poor macro-economic policies
Legal changes (anti-trust, torte)

A major threat is a cut in R&D funding for long term projects. R&D is declining under current budget plans. It is projected to decline from $34.3 billion to $28.5 billion. All it would take is another budget crisis of members of Congress to lower funding below a sustainable level. While we are decreasing non-defense funding for R&D, Europe and Japan are increasing such funding. The two combined already fund at levels above $34 billion. We are trading off R&D for short term responses to social problems. We cannot afford to trade away the future for social welfare solutions.

Terrorism
World-wide transmission of diseases
Downtown of economics
Regional conflicts

Note: Communication (videoconferencing) advances will <u>not</u> deter demand for flying and transportation
Note: Congestion issues <u>can</u> deter demand

In 25 years from now there will be a
New conventional subsonic transport Mach .84

85% of the market
New High Speed transport Mach 2.4
15% of the market
New process for technology
Get A/C to market quicker
Build pieces
Double the price of fuel(Fuel good for 40 years)

Comment: Currently the cost of the airplane is the dominant cost, not fuel
777 cost $5B and it takes 7 years to recover cost
Financial people are running the airlines
Not a good investment in the cold light of day

Back to things that should be taking place in the universities, creativity.

Goal: hypersonic transport should be routine, and interplanetary travel should also be routine.

Revolutionary: hypersonic but been working on it since the 1960s. R&D has been interrupted for funding reasons.

If we discover that hypersonic is not doable because of environmental issues.

The lawsuit situation has not been solved by legistation passed by congress. New designs might still be effected by frivolous lawsuits.
Environment regulations (both noise and emissions) could have a great effect on the growth of the industry. The industry is already starting to address the noise issue and is moving away from lead based fuels.

Derail industry - security concerns, particularly terrorism.

Draconian security measure will impact international travel.

Most of these measures can be done but will have serious cost impacts.

NASA could provide assistance if integration efforts would work i.e. the problem of separate agencies working together.

Major War.
Major economic depression world wide.
Discovery of a very bad public health threat: flying above 40k is ruining ozone, ect.....

Trends to restrict growth
Environmentalism pushing technology
Major changes in world order
Military affect-Civilian reaction
Economic growth
Stagnation-recession
Tilt rotor
Rapid rail
Capacity and efficiency of present ATC system
Free Flight

Safety image could markedly impact future
Software glitches could cause catastrophic impact

Major winners and losers could cause turmoil

Cancellation of V-22

China growth - US depending on growth of sales with China. If this doesn't happen would have serious impacts.

A significant change in liability laws may put an end to mass airline travel due to the increase in insurance cost. This would make travel too costly for most.

World events - could derail events
- Damper - rising national view that Aeronautics is mature technology
- Of all Federal funding - DOD provides 75% for EE basic and applied research, 37% for all engineering, 62% metallurgy and materials
- Point is DOD major force for basic and applied research
- Not good for DOD to think mature technology
- People who had wisdom to invest more in the past turning away
- Opportunities in Aeronautics - could showdown
- Sort on Int. High performance turbine (IHPT) service trying to cut - ready (why rush?)
- Demand side - global infosphere - could reduce need for travel
- to a lesser degree - LTA aircraft or fastships - could displace cargo aircraft
- Not sure country will ever get rail system fixed. If did could cut aviation business
- Not worried about Europe taking away business form U.S. - European Union - big growing pains - 25 yr not enough time to give up centuries of European Bardaness
- In Europe industries viewed as reflection of sovereign wills
- more worried about China - military and economic
- China - eclipse Japan in terms of economic competitor if continue to adopt capitalism - trying in space - could be even more so in aeronautics
- could do an "Auto equivalent" that Japan did in aeronautics - rotary aircraft, turbo props abandoned market left open, can go up to larger transports
- catastrophic event - Continued erosion of work ethic, education level of work force - event come from inside country not external
- USA is the one at risks; education and work ethic are being attacks on all fronts
- what don't want to have happen - lower standards
- elevate people to standard - resist pressure to lower
- Industry - Thomas Jefferson School SAT
b/c of industry
- Modest investment at the high school level would have a great benefit
- Good equipment, excellent institution
- Send industry people on sabbaticals
- Not just getting thru book but turning on to science

Derailment of #4 - Too much emphasis of space research. Distrust between governments.

Derailment - Global conflict - probably biological/chemical.

- Global ineptitude caused by greed.
- Environmental products will be a big product.

An order of magnitude increase in fuel costs would benefit electronics industry and seriously impact airline industry.

- Environmental - compared to other transportation - air travel cleanest.

Derailment - available money.

- Competitors outside NASA - Military could be in the future. No one else is really a valid competitor outside of the US.

Disruption of access to oil.

Continuing congressional criticism of
NASA
Reeaserch and Development
Near term monolithic view

Fear NASA will walk away from Aeronautics enterprise
US will not be a player in future aeronautics

Which could boost: A real threat other than regional wars, will be a thrust to the industry, a bonafide threat is necessary. Transportation will always be important, so a commercial driver.

Worse: nothing really because there will always be an aviation need.

Politics- Congressional passage of new safety legislation that pleases the population but has no real effect to improve safety, but significantly increases cost of operations could ruin the industry.
Economy- Global economy is closed down by increasing tariffs.
Fuel Prices- industry can absorb slow changes, but a sudden jump would be devastating.
Environmental issues- The EPA and "Tree Huggers" could hurt the industry by increasing regulations on noise and high altitude emissions.

Improved communications will reduce face-to-face requirements. Business travel will be more expensive because it will reduce. Personal travel will increase.

Derail growth - Terrorism could seriously impact airlines - might cause an increase in GA traffic. Security measures will be more intense at major airports thus businesses may opt for non airline capability.

Safety- if people lose confidence in the system.
Cost- increase cost on travel will cause people to move to tele conferences. There could also be more competition between light rail and short haul commuter aircraft.

Depends on the Soviet Union

The cost of fuel or a significant destabiliztion of a region which is not likely.

Energy crisis, the cost of fuel.
Terrorism.
Infrastructure, there needs to be more reliably from the FAA system.

Economics.
Terrorism could be a boom to NASA, more research funding.

Economic upheaval or social unrest in US or Russia
Deterioration of Japanese relationship
China is our new enemy and could cause a war?

6. In the context of your vision of the future, what do you see as the strengths and weaknesses of the US aeronautics industry?

Strengths: Capitalism, our companies have always worked under the idea of be strong or die. Our country still has good facilities.
Weaknesses: We are losing our education edge to the rest of the world, our competition is building new facilities to match or surpass our own.

Strengths: We are still dominant in the global long haul market place, 747.
Weaknesses: Dominance in the long haul market place might cause the US industry not to do the need research and risks to bring the next generation of aircraft to market.

Strengths: Still dominated by the private sector, more productive the government owned; people are highly educated with good Universities; military is still producing good pilots and mechanics; NASA's aerodynamics endeavors.
Weaknesses: Airports in the rest of the world are financed by the federal government so they are able to build more facilities, we might need to address a new way to finance our airports to keep up with the rest of the world; our demand for air travel is mature while the rest of the world is growing; other nations have the possibility of leap frogging the US by learn from our mistakes and buying experience.

Strengths: Strong marketing and system integration skills, strong R&D in structures and materials, pursuing engine improvements, competitive edge but other are catching up quickly, can keep edge if focused on cost and composite materials, production and manufacturing skills
Weaknesses: {Non stated}

Strengths: The ability to harness information, understanding of the whole manufacturing process, ability to manufacture cheaply, influx of computer technologies.
Weakness: Our workforce is losing its capabilities and skills

Weaknesses: Competitiveness, not only among industry but also in NASA. In reducing budgets, different projects are fighting for money, the public is not supportive of research and it is not industries positions to do basic research.
Strengths: Very competent airframe and engine manufactures; NASA has provided the infrastructure to provide new technologies to industry.

The strengths and weaknesses of the industry are the strengths and weaknesses of Boeing.
Strengths: Collaboration, risk sharing by companies, companies have great depth
Weaknesses: Airlines are still cyclical, still having accidents and delays; there is more uncertainty in national and international markets; there is more Congressional pork in NASA's research budget.

Weaknesses: Inefficiencies in our infrastructure; Long term research is being diluted; education is weakening.
Quote: "If NASA keeps doing short term projects, they are going to be developing project managers, not researchers."
Strengths: We can rally towards a common goal, we can pull it together.

Weakness: Bureaucracy (not just in government), is there the correct amount of caution applied to new concepts or designs or is it too much. There is no shared vision, the cold war drove the space race but right now there is no national aeronautic sense of direction. Langley is a little dysfunctional.

Strength: People are excited about perceived opportunity; facilities are still world class; university/education, the world comes to the US, NASA tries to support research and learning at the university level.

NASA is doing a lot of supersonic research but the big payoff for industry still lies in the subsonic regime. There needs to be a clarification of corporate welfare vs genuine industry needs.

These are several strengths of U.S. Aeronautics industry: (1) better management; (2) better strategic thinking; (3) much less risk adverse than Europeans and Japanese; (4) much more dynamic or willing change; and (5) more productive.
I really cannot think of a weakness of U.S. aeronautics industry compared to its competitors. Perhaps cost is a problem for us.

Our strengths are the historical successes of our aircraft. This is especially true of our military products.

A major weakness is the industry's tendency to focus on short term issues at the expense of long term planning.

Corporate knowledge is not maintained. HSCT is an example. The knowledge gained in the corporate world through SST research was lost as people were rearranged. Now with HSCT they have new corporate experiences to share.

McDonnell Douglas sent all its VSTOL off. Now with JAST, it has to start all over. Only NASA has a previous knowledge base to draw upon in starting the new research.

NASA can be a repository of the corporate experience. This is a strength of NASA that is not fully appreciated.

US very positive now and keeping lead
Aero industry unlike others is leading the world

Weakness could be industry denial that a problem exists and a new technology development is needed

Strengths: Yankee ingenuity, competitiveness, integrated design tools could really put us in the lead.
Weaknesses: Loss of facilities, risk analyst (every time an airframe manufactures launches a new product they have to bet the farm, if this product fails we will lost one of our major aircraft manufactures), space launch (we need a new launch system to stay competitive with the Europeans)

The one strength is reliability and customer service. The large infrastructure and manufacturing investments of Boeing, GE and Pratt & Whitney permit them to persist in the long haul. Europe may not be able to foster that kind of tie.

There are not any other glowing strengths. It is unlikely that 25 years from now the government will be willing to invest money and technology in supporting aeronautics.

A weakness is the unwillingness of U.S. industry to take risks in the development of innovative products. Too much investment strategy is driven by quarterly financial reports rather than supporting performance over a long period of time.

Our strength is the overall size of the global civil aviation industry; much of work and life style center around access to air transportation - huge market. Weakness is, slow technology cycle of industry. Inability of industry to respond to rapidly changing business. Information technology being a fast changing arena could overtake industry's ability to take advantage of the changes. [Supersonic] Aircraft speed is a strength to business for a small period of time until virtual business meetings become a reality. If increased video bandwidth develops very quickly, it could overtake the advantage of supersonic aircraft speed. In any case, speed will not drive technology or the economy. Aviation is basically a commodity game.

A major strength of American industry is capitalism: you are either strong or you die. A weakness is our education system. We are losing our technical capacity for the future. Lack of funds for universities means fewer engineers and PhDs, fewer jobs now mean the base of talent in future will be smaller.

Another weakness is that we are not investing enough in modernizing our wind tunnels. This becomes a weak link in the chain for major innovation in the future. Europe has invested in creating state of the art wind tunnels. We could get behind quickly if we do not invest continuously in modernization.

The aeronautics industry is too near-term focused. The competitive situation is such that airframe manufacturers expect and demand a ROI within 18 months. This short term focus makes them realize that they depend on NASA for long term technology development.

Strengths:

- the US is way ahead of the game, but that leading is eroding
- aeronautics toward smaller short hauls?

Weaknesses:

- the US has abandoned the regional and commuter aircraft market
- declining education and training has led to a lower quality labor force. Where to get pilots in 2010 is a challenge because not getting them form the military as much anymore.

Strengths:

- the strength of the business lies with systems integrators now. There are increasing layers of subcontracting. This advantage has been learned in R&D but not yet in operations.

Weaknesses:

- US companies do not know how to produce at low costs. They want more sophisticated systems which will reduce risks, and they still want to be able to balance their budgets. That's tough to do. Problem: they are willing to spend money on R&D but don't want to spend more on production. [Editorial comment: odd remark considering the number of interviewees who do nothing but harp on cost and economic feasibility of the product—so does this comment mean that its all talk—complain, complain, and do nothing about reducing production costs??] The purpose of low cost production is to have a manufacturing base which can easily absorb jobs lost by attrition and prepare for high speed production in the event of war.
- The US is not making small aircraft. Same argument as in the auto industry—US companies do not know how to make money off of small planes. Small planes are built in other countries. In the 1980s, US companies said that those countries were losing money on those small planes. Myth?

There are several areas that are currently plaguing the industry. The cost of manufacturing is exceeding what it is acceptable. In addition, there has been limited success in advancing the areas of safety and protection of the environment. However, the future holds the development of high technology that will aid in elimination of these factors as areas of concern.

Another weakness is Europe's lead in government support for civilian air transportation. In fact, Europe far exceeds the United States in its per unit support of commercial transportation.

Only production capabilities are a strength for the industry.

Five weaknesses are:

- The traditional / historical mindset of U.S. industry
- Time to market
- Affordability
- Inability to compete in the international marketplace (stated we are trying to overcome this)
- Need to change thought processes and improve is most critical. He stated that NASA centers need more flexibility

A major weakness in the future will be the lack of smart, innovative people. The base of talented people in the industry is eroding away rapidly as we move from difficult puzzle solving to marginal changes which make a commodity cheaper.

A strength is that many people like airplanes. Aeronautics will have access to other technologies. The electronics industry may provide significant contributions to aeronautics.

Three strengths: understanding the best vehicle and propulsion concepts needed, understanding of the environmental impact of systems and minimizing them, and the ability to analyze the complete aeronautic vehicle and propulsion on a computer with the cost and environmental impacts of the system included.

One weakness: lack of funding and skilled personnel to continue the long-range research required to enable us to reach our goals.

The aeronautics industry is too near-term focused. The competitive situation is such that airframe manufacturers expect and demand a ROI within 18 months. This short term focus makes them realize that they depend on NASA for long term technology development.

We are highly technically competent. However, as industry leaders, we are not aggressive enough. There are times when we are slow in transcending competition and at identifying benefits form technologies. I see our short sightedness as another weakness. The Europeans are far more open-minded and aggressive. “NASA could play a role in probing the US Aeronautical industry.”

One weakness is industry's near term view at the expense of long term opportunities. There needs to be a balance.
One strength is the ability to collaborate in more strategic partnerships. This will help reduce duplication of effort. The future bodes well for this.

Strengths:
Cheap power
Tacit knowledge (of aeronautics)
Large domestic market
Comfortable with climate of competition
Entrepreneurship
Large military budget
US culture
Premier basic research & education
Infrastructure
Existing market share
Customer good will & image
Experience in international transactions
Generally supportive gov't
Critical mass

Weaknesses:
US Gov't policies (e.g. China)
Tacit knowledge (too confident)
(?) revenues and profits
Legal system
Inability to solve business cycle
Labor - management social contract
US culture

The strength of the U.S. aeronautics industry is that we have the most creative and innovative people in the world. Universities, corporate, and NASA personnel make a highly creative team.

The weakness of the U.S. aeronautics industry is that airframe manufacturers in particular have not been aggressive in getting their story told. The aeronautics industry has been complacent in arguing its case for more R&D funds. Electronics has done a better job in selling itself.

Strengths
Strong economic support of DOD
Education of U.S. population
Consolidation of U.S. Companies

Strengths:

- We have the ability to achieve when we put our mind to it and have the resources, but must be used efficiently and at a low cost.

Weaknesses:

- lack of willingness to do it.

Strengths: The US has a great tradition, pride, corporate knowledge, industry and social economic support and a will as a nation to support R&D. Our industries are efficient enough to develop new products and new ideas.
Weaknesses: The Roman Empire factor, too rich, too fat, could kill us; we are better catching up, not leading.

Strengths: Free Flight (this will help both commercial and civilian aviation), modernizing of the system, political backing of NASA, we are in a better position as far as industry and demand, NASA support of aeronautics (much more commented than the FAA)

Strengths: Our growth in electronics capacity, we are the best in the world, however Japan and Europe are closing; Operation and Maintenance, we build things that are easier to maintain then the Europeans
Weaknesses: Political System, NASA support could disappear and industry needs NASA support to make leaps in technology

technology (CAD/CAM) utilization is a leader
We have neglected commuter (30-100 seats) aircraft development

Weaknesses - Companies that do not want to improve even though technologies are available. Terrorism, fuel, better efficiency at lower cost.
Strengths - Technology base with people to implement it.

Strengths Infrastructure, Expertise, R&D,Commercial airlines, Resources, US Acaademia
Weakness In we become fat and lazy and are no longer hungry enough

Strengths of the US are the will to succeed and the US people
Weakness would be our loss of the will to succeed

Weaknesses:

- only airplane nuts going into the industry

Strengths:

- Women make good engineers. There are a decent amount of female engineers; it would be good for the industry to attract more. Attracting women would also help deal with the testosterone factor which is dissuading male engineers from working on planes/projects which aren't as sexy, fast or big.

Strengths: GA companies are willing to work together, support from FAA, excellent engineers
Weaknesses: Because the industry is not closely monitored it is hard to get a real number on the number of people that are affected or use general aviation, so it is hard to get support of something that you can not prove has a large effect on the economy.

Strengths: US is still ahead in R&D, Education, capitalistic system makes US stronger
Weaknesses: Less support coming from government and industry will pick up funding levels to do more research, foreign nations still support research, aging fleet put a major strain on airlines, aging infrastructure (FAA facilities), we are not producing enough engineers

Strengths	Weaknesses
Low Cost products	Short term outlook
Efficiency	Where to spend money?
Drive costs down	Near term payoff?

Strengrths	Weaknesses
Ideas to market sooner	Long term focus
IPT approach	
Rapid technology insertion	

Strengths: Good solid base in aeronautics in this country (Universities, NASA, Companies), Industries are doing fairly well causing a need for more airplanes and NASA.
Weaknesses: Reduce government debt

Weakenesses
Nobody on the business side understand aeronautics and enginners are not trained in business.
US is watering down it's educational system (Enineering used to take 5yrs-150credits and now it takes 4 yrs-120credits. Top MIT Engineers go to Wall Street now!!
Lack of Passion for Aeronautics
Inconsistant long term focus.

Strengths
Embedded fleet
Best in Simulation and Controls
SW/SW Management
First rank in propulsions and materials science

Comment Only 50 people in US understand transmission technology

7. Imagine an operating environment (25 years from now) that you would consider the worst nightmare for the US aeronautics industry. What are the characteristics of that world?

Some invention that would replace the need or desire to "be there".

A foreign competitor comes up with a new technology and can keep it quiet long enough to get a foot hold in the market before we could figure out how to copy it.

A foreign competitor develops a efficient high speed long range transport to take the place of the 747.

Security issues and possibly running out of oil.

We have limited resources, and if industry will not work together and with NASA to save money we could be in real trouble. NASA need to take the lead on this issue.

Completely run out of oil because there is not research now or plan for the future on alternative fuels.

Total electronic media, no more face to face communications. "You can manage electronically, but you can not lead. We are no longer understanding people."

People perceive that aircraft are not safe , over compensate with regulation. People would get away from the face to face meeting and rely on telecommunications.
Cargo would still be moved by air transport.
Some of the airframe manufactures would go out of business, most likely Douglas.
Technology development would continue and the industry would survive as long as there is an economic benefit.

Cost of Energy increasing dramatically.

My greatest nightmare is a lot of accidents in a short period of time. What if we had five accidents in three months? Moreover, these were not unique accidents. Rather it was determined that the accidents were the result of structural management problems (Valuejet type accidents).

The government would lose confidence in the system and impose such tight operating rules, that is, so over-react that the system could not grow. We might slow things down for fifteen years.

If the aircraft of the future rely on computers and fly by wire, I can imagine a weapons system that can knock all that out. This would be a disabling act that could really put aviation back in the dark ages.

A Bosnia -type world with sectors and blocs

A really strong collation of European countries (Germany, France, and Russia) go after the HST market.
An Asian block (Japan and China) go after the Pacific rim market across the board.

A worst case situation is a European Community and Russian alliance to create a lower cost aircraft. The U.S. share of the world market has declined to 50 percent. This 50 percent is critical to maintaining the industrial base in aeronautics. A decline below 50 percent and the subcontractor or supplier base will erode. There simply will not be enough business for smaller suppliers to survive. Boeing will not be able to maintain a U.S. supplier base.

The military market is shaped by Congressional policy. A decline is appreciation for military assets could destroy the military aircraft manufacturers. The back-draft impact on the commercial side might undermine the ability of the U.S. to maintain a supplier base for even commercial manufacturing of aircraft.

My worst nightmare is that a competitor builds a new system and we do not. A candidate might be an engine that uses only 50% of the current fuel of our engines.

What if our estimate of our fuel reserves is wrong?

For aircraft suppliers: that people stop buying planes because disposable income decreased + terrorism.
environmentalism—carrying capacity issue—airports are unable to sustain the increased air traffic re: congestion, pollution and noise.
prolonged regional conflict? Is an increased military budget a good world for the aeronautics industry?
**the will be a backlash from the arms trade on the US, because we'll be fighting against our own weapons/ flying against our own planes—so not in the interest of the aeronautics industry.

The threat has less to do with technology, but instead with certification. The US dominates standards but the balance of power is shifting. If the US loses control of aviation certification standards, it will have a major impact especially if it goes to a nation that owns its own aeronautics industry that it wants to promote.

The cataclysmic event would be a fuel shortage.

Terrorism—freewheeling and uncontrolled attacks.

If US companies cannot continue R&D then they will be overtaken by other countries. The US is good at fundamental research, *but it is not good at helping industry reduce the risks of applying new technology*. Perhaps Airbus is better than Boeing at reducing risks.

800 passenger aircraft by Airbus, recession, no capital to compete although none of these trends exist today.

A balanced budget is coming but this should increase our strength: One half of current budget is social insurance. Aeronautics has to be smaller bur basic research sells.

The greatest nightmare consists of the U.S. industry failing to get its costs at a manageable level, or building an unsafe aircraft. The U.S. industry needs to stay competitive in addition to keeping its market share.

The worst nightmare for the industry would be to not have a product that is competitive to offer the new market. This may result due to our tendency to engage in near-term thinking.

A worst nightmare is that technological development stagnates because the manufacturers determine that aircraft production is merely a commodity business. Another nightmare is a significantly reduced supply of fuel.

Advancement of telecommunications technology that significantly cuts business travel.

As you advance computer technology, a lot of jobs of high quality will be lost. How will we continue to make productive use of these people? Where will the engineers go?

I can't see any catastrophic event happening - change will be gradual and we could be our own worst enemy.
The industry has been down-sized or should I say 'right-sized.' At present there is no dearth of qualified personnel but this will change in the future. Aeronautical engineering will not be very "rewarding" or "stable" in the next 10-15 years.

Lack of appreciation, understanding, and support for NASA by Congress leading to major budget cuts that necessitates reducing some operations and these are aeronautics. Other things can be worked on by NASA; this one cannot. We must educate Congress about the broad role of NASA and Aeronautics in particular.

Instead of a "world" he provided a "bad things" list:

- Dramatic increase in fuel costs
- Very efficient ground transport
- Travel restrictions
- Lack of capital
- Increase in "in-air" time
- Buy - American / Japanese / European / etc.
- A US foreign policy antithetical to business
- Health hazards for the nature of flight (e.g. radiation)

The greatest threat to the U.S. aeronautics industry is to allow the Europeans to build the next generation high speed civil aircraft. This is the entire 747 replacement market as well as new markets. Complacency is the greatest threat to the U.S. Thinking that aeronautics is a mature industry which does not need government support for innovation is a major handicap. To survive we cannot think it is business as usual. We must change the paradigm. The U.S. aeronautics industry is not on the point of maturity it is on the precipice.

Terrorism
Diseases

Discontinuation of funding for research on the part of the government. Ex: Gulf War—20 year old technology was used. If government R&D were suspended wouldn't be able to catch up or get people.

Environmental issues, if it is proven that emissions from aircraft are contributing in a special way to global warming, their use might be restricted.

A major accident once a week could change the whole out look of the aviation industry. This could get congress to add legistation to constrain the capacity of the aviation system. However, a good accident could get Congress to give the money necessary to the FAA to moderize the system.
If airlines ruled the skies and left no room for general aviation.

No more fossil fuel, this would eliminate aviation as we know it.
Total collapse of the US political system, a disappearance of governments role in industry.
A rash of crashes is not reasonable nor is a change in the public's attitude toward flying.

Isolationism because of fear or world unrest.

- If something replaced airplane -
Strengths of US aeronautics
Strengths - technologies advancements, response to market place, safety and reliability.
Weaknesses - compete with each other.
- More consolidations
- Uncontrolled Terrorism - Greatest nightmare
Exclusion vs Inclusions - Inclusion - viability of business - maintain dominance.
Air Cargo - If somebody did it - could dominate market.
- Center redundancies - Integrate centers. Be willing to let go of old technologies. Center autonomy is a problem. Too many centers are doing the same things.

Safety (accidents) could derail aviation-system
IT and automation are inducing risks that could undermine industry growth

Complete loss of market
- Domination of market by other countries (cheaper labor (i.e. Korea))
- Loss of technological leadership

The worst nightmare is a government that has an extreme policy that pulls money out of research and puts research in the hands of industry. Government would only participate to protect safety. Everything is privatized. This happens so fast that Aeronautics cannot transition to an industry that can live off its research. If it happened slowly, Aeronautics could probably transition into industry.

Also, if Aeronautics were subsumed under DoD for the only R&D performed by the government. This would be disastrous for the industry. Government would participate in civil development only in that it would spin off technologies.
Such changes are more threatening than liability.

The worst nightmare is that Aeronautics is subsumed by Space.

Nightmare - Loss of support - public interest, resources, micro management.

Nightmare? None really except for those covered #5. Communications and transportation are inhibitors to nightmares.

Aeronautics nightmare in 25 years - virtual aeronautics electronic mail, televideo conferencing, available and people will not want to travel.

Nightmare US Areo - No technology investments - US industry is overtaken in competitive edge.

Apathy becoming second rate

Regional/multi regional war.
Plague that reduces the population.
One worry that has been brought up is, if we keep the same accident rate and increase the number of flights each day, we will have an accident a week. This in not a big problem to aviation because if this happened slowly over time, people would grow accustom to the accidents, kind of how we now look at car accidents.

Not economics. Any situation that could cause major fear or threat to lives would seriously impact.

What is the major issue - No high comfort level with NASA ATC work (CTAS).

Safety, world wide terrorism with smart weapons; increase number of flying, safety will have to improve or we will have an accident a week.

Other countries divide market, US cannot play-Antitrust laws

World peace and quadrupling of fuel prices

Loss of public confidence for any number of reasons.
Military, there is no real threat as long as we keep the systems affordable.

A government leadership that did not feel there is a requirement for a strong technology base, concentrated on social issues.
Fuel shortage, bad economics.
If we got behind the Europeans, it would be very hard to recover once behind the power curve.

Full scale war
Emergence of Isolationism

8. Now we would like you to think about the range of global external forces that may shape the future of the demand for high speed transportation and delivery services.

Selection Criteria:

Absolutely crucial; those that could have a very positive or negative influence, Important but not critical; could be boarder line influence, Relevant; things that the world will get over or the industry has a record of adjusting to.

Decisions were based on previous discussion on what he thought the future might look like, market issues, environmental issues, technology break throughs and time to market

Crucial: Things that by themselves could change the industry
Important: Things that when in combination with other events could change the industry
Relevant: Things that did not rise to the important level.

Security issues were critical.

Things that were critical; access to world markets, nontraditional markets, cost, and R&D budget

changing market environment, international markets, political/world stability, internal capacity/infrastructure, profitability, international markets

The crucial technologies were those that address international aspects of what is happening in the industry. The US can not isolate itself, it is growing to be important in the future to differentiate yourself from the international competition. Technology break throughs are going to dictate who will be the strongest player.

Gut level decisions based on what are the areas that will drive the industry based on past experience.

Things that are key to having a strong aeronautics industry, being able to adapt to the market place, external threats to the market place, and the ability to adapt technology.

The ability to bring a product to the market place or expand the market, safety

The critical pile consisted of topics that effect business growth and getting the product to market.
The relevant pile consists of topics not as important because the could effect the market in only a general way.
The important pile consisted of all other topics.

My top critical forces are 19, 14, 13, 27, and 31. I really was influenced by forces that would require government intervention in selecting my critical cards.
Presently the driving forces for technology in the future are supply and demand. This is what shaped my choices in the critical category.

Things that were rated as crucial had an effect on demand. Important concepts were those that effected how products are developed.

An unanticipated breakthrough could have a huge impact. GPS use was not anticipated, now it is a major factor in the industry.

Many of the topics in the crucial category are things to which NASA may not be able to contribute.

Choices were based upon commercial airlines, not military aircraft. Concepts were deemed crucial if they would keep the U.S. out of the aeronautics industry in the future. A classification of important indicated that the U.S. would still be in the business, but these things would need to be continually monitored and dealt with as challenges to the market.

Access to space, the future of work, environment(alism), intellectual property, alternatives to air transportation, and unanticipated technology breakthroughs were identified as the top priority of

the crucial concepts in the cards. Intellectual property could really have an effect. Also, alternatives to air transportation and unanticipated technology breakthroughs were linked concepts.

I used an effects approach to sort the cards. That is, I considered the effect on market growth or greater market share or ability to get the job done (without it you cannot do the job).

Sorting Theory: Critical

> A critical issue is one that will have a fundamental impact on the way the business is run. {he failed to elaborate on what a fundamental impact was}

For crucial category, I asked if the card represented a market for aviation in the future; what would compete with aviation for market share. For important category, I asked if government policy was an influence; and considered the nature of society. For neither crucial or important category, I made a judgment based on the title alone.

The criteria for selecting the critical cards was whether they shaped or were relevant to global market issues, limited resource issues, or surprise.

Didn't see any potential blindsider from category 3
His definition of "crucial" implied that if we didn't effectively deal with the issue, then something bad would happen to the industry. Category 2 cards are "worth paying attention to" but aren't "make or break."

He determined that issues were critical based on this concept: what are the drivers for air travel and what are the impediments to air travel; so the health of the industry depends on a good market. Therefore the worse thing that can happen is that the market disappears →
Critical issues are those which drive <u>demand</u>:
tourism and travel are going to be the biggest industry in 2016. 2016 will see an aging population with increasing disposable income in the mature markets, and an emerging middle class in the EMs.→ money to burn.
The world is in motion. The response to that is what's important → **need to worry about peripheral infrastructure → do cities have the ability to handle increased tourists simultaneously

Sorting Criteria: he didn't really share that with us, all he said is that he would mention the issues that he thought were important and not mention those he thought were not important!

- Affordable travel: fundamental, driven by demand for air travel
- Alternatives to Air Transportation: video conferencing and virtual reality are high threats because the airline industry is a "business" driven industry instead of a "leisure" driven industry.
- Cost of energy—important
- Environment(alism)—threat overhang—noise abatement, emissions, more critical
- Ethnicity / Religion—significant direct impact but no specific comment
- Free Trade, Integrated Markets & Harmonization-- significant direct impact but no specific comment
- global Conflict & Political Instability-- significant direct impact but no specific comment
- Government Debt-- significant direct impact but no specific comment
- Wall Street—Airline not a good business because of thin operating margins.

The sorting criteria was A most tangible, B lined to A, C least tangible

When evaluating the cards, the criteria which was used to determine the category to place each in was based on cost. He also pointed out that safety was not among the cards. Liability is important mostly for small firms because one accident can put it out of business.

Many of the cards were placed in the important category because they are only one element of cost.

The criteria used to determine if something was crucial was the impact of the elements on the future of the industry and the role it might have in the future. Some of the cards were not directly related to the subject of the future of the Aeronautics industry.

It is not clear that the Aeronautics industry can stand by itself to get to the next stage of the market. It will need government to act as a partner and to provide support.

It is unclear whether intermodal travel will be a reality in the future.

Comments: I picked the critical cards based upon the sound byte level. Certainly affordability was paramount as was U.S. competitiveness.

Things that he included in the crucial category were major drivers. He rated alternatives to air transportation as the most crucial of the concepts included on the cards.

His definition of "crucial" implied that if we didn't effectively deal with the issue, then something bad would happen to the industry. Category 2 cards are "worth paying attention to" but aren't "make or break."

I've kept in mind the three forces crucial to this industry - affordability, environment and safety. I'm not sure how to categorize terrorism. If it escalates, it could threaten the industry. World/regional growth is important but is fairly well forecasted.

Air cargo falls between important and unimportant.
The Ethnicity/ Religion card could be moved up as high as crucial depending on how it is conceptualized. If it is understood to mean learning to live together in spite of religious and ethnic differences, it may indicate an increasing desire to travel among the world's population. However, if it is conceptualized simply as ethnicity and religion itself, it would be unimportant.
Those things that were crucial were determined by reflecting on the interview and experiences and then making decisions implicitly.

In stack #1 if it affects the ability to sell airplanes as a function of willingness and ability of consumer to fly (or a dramatic shift thereof)
In stack #2 if it is important to manufacturing but it may be a constant

Comments: The crucial category was defined by my notion that the item listed enabled U.S. industry to be more competitive. A crucial item was one that most directly affected the aeronautics industry. Those placed in the important category were, in my view, common to many types of industries.

Card #1 (Cost of Capital): Currently a new aircraft will cost $17 billion in R&D. If inflation becomes high it is likely to prevent investment in new aircraft development.

If you privatized NASA it would move from the important to the crucial category. If privatized we are compromised in acting as a third party or as a catalyst. Privatization would raise revenue issues to a prime focus of our research. It would make us one of the competitors.

Free trade is the most important of the cards. Government R&D budget is second. Third is the location of manufacturers. We must be careful that we do not think of ourselves as brokers. We need to make sure we do not give up high technology manufacturing to other countries. Global conflict is next. Affordable travel is also highly important. The airlines have told Boeing the they will only pay $200,000 per passenger seat for the next designed aircraft.

Issues that could really damage the industry were placed in the critical pile.

Things that would affect either the supply or demand for small aircraft were critical.

Integration of intermodal transportation. Should be part of future transportation.

Critical: These were issues that if there is going to be a major change in the industry, these are going to be the drivers.
Relevant: Issues that are not a problem, could be, but do not see them as one.

current marketplace, future marketplace, workforce will be more global.

Those things rated as crucial are the things that must be addressed. They must be dealt with and be a positive factor in the industry in order to succeed. These concepts are both challenging and pose the threat for derailment.

Things rated important were deemed workable.

- Tie income distribution and government debt, also Wallstreet and capital linked
- "Cycle time" his definition of time to market
- Mid priority - offsets less important, industrial policy more (did not include issue of tax breaks/credits - include in government R&D) mfg location - lower cost compared to offshore. Demographics - greying workforce - greater annuities - affect budget, tax policies, but pressure investments. infrastructure fluidity - affect VSTOL. Free space flight - get away from ATC. Liability - lawyers impact.

Sorting Theory - #1 trust between organizations, resources to do job, #2 application of the mission.

Sorting Theory - Based on the described future and the impacts on them by the domains. Piles #2 and #3 are closer together then #1 with 2 and 3.

Sorting theory - market pull (critical) -1 Required but not critical (important) - 2 Not required - 3

Sorting theory - Tried to segregate by what the key drivers are to the success of aeronautics

Environment for the continuity of business

Environmentalism moved to critical because of ability of weather country company dominating market.

Potential level of impact was the key criteria.

1) Leverage and variables that would have the most major demand are air travel - Major impact. 2) Less of an impact on aeronautics. 3) Economics doesn't have a major impact.

Critical issues were show stoppers, could ruin the industry.

Important issues were those that to be successful in the market place you had to pay attention to. Relevant issues were those you did not have to worry about.

Things that by themselves could have an impact on the industry were critical, things that could have some how effect the industry were important.

Choose one of the items, and tell us how that item could blind-side US aeronautics.

No, non of these issues could by themselves could effect the US industry.

There was nothing in the relevant pile that the US industry could not handle.

Air Cargo might have to move to their own airports.

Infrastructure: The rest of the world is building world class testing and design facilities and our facilities have frozen in development.

Public Health

Terrorism and Privatization.

R&D budget, the airframe manufactures would not be successful without government support.

Terrorism and the cost of energy

Global warming might be a side issue.

any of the issues potentially. Used public health as an example.

Didn't see any potential blindsider from category 3

There can always be a surprise, but industry has shown that it can handle issues in this pile.

Environmentalism - More concern about this subject will increase

Unions - Strike, Public Health - Eboli

Notes on stack 1.

Liability and Tort reform is critical for GA industry but not commercial.
Alternative to air travel: Thinks it might be important but not really
Location of Manufacturing: important politically but not to the industry
Barriers to entry: very important, if people close entries to trade it could have a devastating effect on US industry.
Time to Market: High speed commercial is key
Energy: The highest factor
Government R&D: Fundamental, the contribution by the government is significant.
Environment: Flying more and polluting more, this could inhibit HSST
Global Conflict: Could happen, a closing of airspace would be detrimental to the industry.

Access to space: risk management
Cost of capital: government will not supply money, wall street will have to supply some of the funding.
Terrorism: We need to have a global response capability.
Expanding markets: In the Pacific rim we need to be ready to take the initiative in the market place.
Cost of energy
Time to market: We need better integrated design tools.
Entertainment: We need to make flying more fun.
Public Health: Aircraft cabin are a good place to be exposed to pathogens
Government R&D: Mentioned above.
Tech break throughs:
Education: Concerned about the passing of the torch of skills to a new generation by industry.

Access to space: Not critical to aviation, but it is critical to the world.
Education: Could be a real problem in the future.
Terrorism: Only because it is current and on everyone's mind, might not be a problem in 25 years.

Labor will not be a significant factor.

Intermodalism and infrastructure fluidity do not belong on the same card.
Privatization of the FAA would be a problem for GA.
Tort reform is not needed. The reforms that have been carried out are enough, the proof is in the fact that the GA industry has rebounded.

Market: Being driven by other markets outside the US.
Global conflicts: Terrorism, but political instability is determent to world travel.

9. What should NASA Aeronautics be willing to give up?

Neat technology that does not have a large payoff on the system as described by the end user (airlines).

NASA should give up its focus programs, many of these areas could be picked up by industry. NASA should concentrate on high risk, high potential payoff programs.

In broad term, the focus programs have more impact than the base program. In the focused technologies the companies are more motivated to work with NASA.

Exploration of space, give up a portion of the space program to keep aeronautics moving forward with new aerodynamic and engine designs.

NASA has been cut way too much and it is the poor step child to a lot of other government agencies. So he does not feel there should be any more cuts.

There will be more infuses on our focused programs to determine what are the near and long term needs of industry. NASA has to look into things industry can not afford to, focus research on future systems, not just have free flowing research projects. Wind tunnels will make the difference in the future, we must invest in new infrastructure today.

NASA should be out of super computing, or any kind of computer design or development, industry has this well in hand.

Did not agree with the premise of the question. Every project should under go a cost benefit analysis as a means of determining project strength. If the pay off is there, then every project should be addressed. If a project has the potential for a high pay off some one in the world is going to be working on it, NASA better be the one that develops the technology, failure to lead in technology break throughs will kill our industry.

Near term research activities need to be disinvested in somewhat. There needs to be a balance between near, middle and long term research goals. Research projects need to be prioritized with the benefit of the research directed at the tax payer rather then the industry solely.
There is an over investment in GA.

NASA does not give things up, this a big problem with the agency. They need to be able to evaluate our problems and determine if there is the right mixture of research.
Focus programs have the most benefits in the communications with the customer, not in the actual research.

Propulsion, the current research is closely aligned with what industry is doing and they could probably do a better job themselves.
Engineering Analysis: what went wrong and why did it fail is not a job for NASA
Get out of near term projects and let industry pick up the research they deem important.
NASA needs to learn how to get out of a project when its benefit is deemed low.

NASA should expand the Aeronautics program. The aeronautics industry is not as glitzy as space but the return to the US economy is much greater.
Give up Air Breathing Access to space.
The lose of key "smart" people could be a great blow to the US as DOD contracts disappear.

NASA should not take on an industrial role. It should focus on basic research, which it can usually do better than industry. Industry and NASA are working on a major software package for air traffic control. This is not an appropriate role for NASA. Tasks like this should be left to the industry.

Improving manufacturing technology is also an industry function. NASA could contribute, but it should not play a leading role in this type of research.

The NASA-Army joint agreement on rotorcraft is a model of how things should be done. Army has access to NASA facilities and NASA can use Army personnel.

NASA should avoid redundant efforts with the Air Force and Navy.

We should think of ways to make our research applicable rather than just issuing a report. We have been hammered on in the past that what NASA produces is late and not terribly relevant.

Less military more civil

There should be less effort in the near term as far as research goes, industry should be doing this type of research.
Governments function should be in high risk technologies with high payoffs and maintaining facilities for all of industry.

NASA should get out of the subsonics and general aviation portions of the industry. It is the old stuff. We must get out of the mindset that NASA does the old line incremental stuff. An exception to this would be work in environment and safety. However, we must get out of the old incrementalism. NASA getting out of general aviation should be first.

Liability and tort reform is a red herring.

The U.S. will not get back into general aviation production in any big way. Overall, the general aviation market is hopeless. General aviation propulsion, however, is promising because breakthroughs could affect the world market. That would protect intellectual property and protect jobs. The propulsion systems would be "needed" around the world, airframes would not be built here, but the engines would.

The respondent was asked if he felt we had overlooked something.

There should be more questions about the history of aeronautics. We can learn a lot from the past and then view progress. Seeing these changes would influence where the curve would go 25 years from now.

We should also tie in potential synergies. How can new technologies be spawned into other industries? He used the example of general aviation engines being used in industrial machining or to cross out into space.

Access to space and hypersonic missiles may give us a use for ramjet and scramjet technologies.

Shift balance to invest in markets that could shape the future. There is presently no investment in general aviation and improving *sub*sonic transportation. SST [HST?] is a future (temporary) market. NASA should aggressively seek role with DOD for radical aviation technology. Presently, the percent of military NASA activity is greater than for civil. Stronger emphasis should be placed on GA and less on making the next “707”. NASA could establish itself as technology arm of FAA for safety and R&D. NASA Aeronautics should spend less of NASA’s dollars and more of other’s money. DOD and FAA technical centers should be given up for NASA to conduct activities of those offices. NASA Aeronautics should not give up any programs it considers crucial.

Many of the focus programs are conducting research that the firms could do themselves. There is some truth to the charge that we provide corporate welfare. We should limit research which the firms could conduct. This would permit us to direct more resources to high risk-high pay off technologies.

Right now aeronautics is subsidizing space. Aeronautics’ budget is $1 billion, astronautics is $12 billion. The potential exists to significantly reduce the cost per pound of putting something into orbit, due mainly to aeronautics, not astronautics technology. Perhaps the space budget ought to pay for some of this.
NASA has done a poor job of prioritizing strategy for the long term. NASA is coasting on the strategy set out 10 years ago. Our poor job of paying attention to strategy requires interaction with all players: airlines, manufacturers, DoD, etc.
We don’t know what should replace that which we’re working on when a program ends.

If NASA is to survive, it shouldn’t be completely independent of its customer. It must realize that not all research is equally good; instead that the research must be consumer driven because knowledge for the sake of knowledge is not productive or efficient—
critical focus should be on wide-body, medium body, engines, concern with environment;
Exploration of hyper and super sonics is more a question of economics than technology.

NASA should worry about /prioritize evolutionary advances in aircraft in terms of environment, noise and efficiency (waivers on this).
NASA should look at what it has learned to date and what is really required of it and the aeronautics industry.
Analogy to auto industry : regs for 75 mile/hr car raises the issue of what's the infrastructure to support this, the implications, and cost demands.
NASA needs to make sure it knows what the market pull is.
As a nation –we tend to look for the technological breakthrough –the silver bullet, but not many silver bullets left.

Additional Comments:

Industry dynamics which affect supply?
Airbus and Boeing→ industry consolidation
How much does government R&D contribute to commercial R&D? Not sure how important that is
Institutional alliances—
**certification—time it takes FAA to certify aircraft and time it takes foreign competitors to certify → certification partnership → NASA could get involved in process for air worthiness certificate → role which could be augmented by NASA
R&D
Arena where aircraft industries benefit –niche of aeronautics as human factor research--**how much information can humans absorb → research being done at Ames. Information underload v. overload—niche → as a nation we could take a lead in this.
Talk to Boeing and McD on hyper and super sonics
Crucial R&D is so small compared to other capital investments—has to be integrated activity super and hyper sonic programs would be hard to get through Congress
Break-even hard to reach—have to sell large volumes to recover initial capital investments.

Viewpoint of:
Politics, institutions, economics to look at whole aviation enterprise—NASA doesn't do it –needs to be done → strongly recommends that its legitimate research. Need to understand the political implications. **Once understand the global aviation enterprise, will understand the aeronautics subset → this thinking is counter to NASA!!!

NASA's priorities should be:

- Human performance work, because it is critical and underfunded.
- Safety
    - safety and security are organized differently in the company. Safety for Delta's purposes means aircraft operations in the broadest sense. Although this distinction between safety and security is being blurred in many airlines.
- Deterrence for terrorism: the primary focus should be on people who have boring jobs—they get low pay, and have low motivation, and they are the ones responsible for detecting threats. [Good point—think of the expression on the faces of all those security people at the airport security check.]
    - The FAA has recently started human factors research regarding terrorism. NASA is not currently doing this research.

NASA shouldn't be involved in land/ground issues—ATC, airports etc. These areas should be left to DOT and FAA.

Comment: NASA needs to get off programs Du Jour and get their real priorities decided.

The two areas that NASA should technologically emphasize include : (1) safety and (2) compliance with environmental regulations. In order to achieve these goals, NASA should force industry to pick up research on the short term technologies. If industry can incorporate the short term necessities, NASA can concentrate on development of the long term technologies.

NASA should develop a technology and skills development model for funding the development of a skilled work force. We need to continue to develop U.S. resident skills. Such skills are always important, but it is not always recognized as a reason to do business. This factor needs greater focus because it is where base work and research is. We must make efforts to make the development of a skilled work force identifiable to the end product.

Funding needs to be protected so that current programs do not take money from future generation products. For an example, if there is a problem with the existing fleet that must be addressed, money may be reallocated from the space station program.

Money must go to future research and development as well as to near-term problem solving.

I would opt for strategies and missions which place NASA in the position of working long term technological problems. We should de-emphasize those projects which focus on the short term. We should also cut programs on which we have pounded for years and have not been able to solve. Curve aerodynamics is one. We are not likely to get more drag count out for our money. Moreover, this is a job industry can address. If we are asked to do development work for industry, it should pay. We should pay for research, industry should pay for development.

While HSCT is a challenge, we are not ready for it. It needs to be done sometime, but maybe in 2010 or 2020. This would be the area to be deleted from budgets for the next several years.

Access to space should also be eliminated until a later date.

Finally, we should not work military systems unless we can pursue them as logical spinoffs from other technologies.

We believe aeronautics are subsidizing space. Aeronautics' budget is $1 billion, astronautics is $12 billion. The potential exists to significantly reduce the cost per pound of putting something into orbit, due mainly to aeronautics, not astronautics technology. Perhaps the space budget ought to pay for some of this.
NASA has done a poor job of prioritizing strategy for the long term. NASA is coasting on the strategy set out 10 years ago. Our poor job of paying attention to strategy requires interaction with all players: airlines, manufacturers, Dod, etc.
We don't know what should replace that which we're working on when a program ends.

I am not aware of the NASA's various operations but I think high priority should be given to high speed commercial transport as this is economically viable. Advanced subsonic technology is another high priority area. It is important that NASA distinguish its role from the DOD, particularly in real supersonic arena. This remains unclear and neither entity can justify their role in this area.

Subsonic investments should be considered thoroughly. The pay offs are not necessarily there. Delete those things that are not enabling to NASA.
Continue to invest in top priority technologies in high speed until they no longer make sense--if something shows no promise, stop funding. Be aggressive until the answers are no longer there.
Downsize the military investment. Make DoD pay the lion's share for military technology. Make good strategic decisions about these technologies.

Cut funding for hypersonics. There is not a need for so large an investment in this. We need the program, but not at the current size of investment. Make DoD pay for more of the development costs. We need a national hypersonic program that is unified with only 1 core technology program, not duplicated efforts in different agencies. A concerted effort should be undertaken to prioritize the tasks for hypersonics and then work on each task until it is resolved before moving on to the next one. All work should be incorporated in the same program.

Anything best done by industry or someone else
Why should we do it just because we always have?
Old technologies
Duplication that is NOT for competition
Anything at which we are Third Best
Maintenance, modification, modernization of obsolete or obsolescent capabilities
Unused record keeping
Internal (non-value add) reports
Programs with NO:
High potential payoff, **OR**
High probability of success

Our approach should be to discover what capabilities we will need for the future, then go get them.

NASA aeronautics gets only 4 to 6 percent of the NASA budget. About 95 percent of the budget goes to Space. Of the $14.4 billion budget in 1994 less than $1 billion went to Aeronautics. Pressure should be placed on Dan Goldin to maintain a healthy aeronautics R&D budget so that we can improve our trade deficit. You get far more for the U.S. economy from the 5 percent invested in aeronautics in terms of trade deficit reduction than the equivalent spent on Space.

There is nothing that should be removed from the Aeronautics budget. The sacrifices should be made by Space. It is not time to consider strategies of retreat. We should attack. We should consider the best attack strategies.
Your questionnaire did not touch on training issues. Greater emphasis should be placed on the role NASA plays in training the next generation of engineers and scientists. We need to help create people who are discovery oriented. What we are creating in this country are point and click people.

Techniques for inspecting aging aircraft (airline should do this) near term
NASA do more in safety and environmental
Things that market place could/should fund themselves

Near term evolutionary improvements to aircraft
Aging infrastructure

What is really happening is that attrition is losing the best people and all centers are taking small losses with no improvements

What's on the priority list?

- propulsion because it requires 10-13 years of development. Research to product development takes a long time. Need basic research work in materials.
- Difference between NASA and DOD: NASA is stronger in house in R&D than DOD because DOD buys its R&D from companies.
- Aeronautics should receive more attention, we need a national aeronautics policy.

Research is not profitable, especially long term.

NASA can and should give up affordability. This amounts to 45^% of the NASA budget. Industry can do it better.

Did not know how the budget is divided for NASA aeronautics and only follows environmental issues, so could not really say what might be cut. Believes that NASA need to reassess the SST program and NASA needs more customer focus. Focus programs get more support for industry which would help NASA's budget.

Did not have a feel for all the areas that NASA was involved in so it would be hard to say which areas they should get out of. But, NASA needs to look at and fund the projects that would not get done or would take a long time to market without support from NASA. Some of the inefficiencies seen in projects were not caused by NASA, lazy industry people take research money for granted and did not produce.
NASA should look to research areas where they can get buy-in from industry, 50/50 split on financing research. They can give seed money and avoid anti-trust laws to build constoria to deliver products and set industry standards.
Cycle times in industry are getting shorter and shorter, NASA has to develop a new way of doing business to keep up with these shortening research cycle times.
The success of the small aircraft market in the future is dependent on what is done right now. If NASA and industry handle the issues addressing the market, we could see an order of magnitude increase in small aircraft usage.

NASA has truly trimmed itself back. Everything they are doing is key to long term industry development. All the areas are important, some areas however might be able to be cut back if another agency could pick up the research, such as air traffic management. The FAA would have to step up and prove they are committed and to do the research on a new air traffic system. This would allow NASA to concentrate on building new aircraft technologies.

NASA can and should give up affordability. This amounts to 45^% of the NASA budget. Industry can do it better.

Materials testing
Basic research (as compared to focused application)
Incremental knowledge to improve aerodynamics performance

Survival niche for Ames, being the technological development center

Doubtful that NASA will be able to stay ahead of information technology.

NASA should concentrate aeronautical engineering at Langley.

Although its facilities are unique, there's no reason to support two discrete facilities at Ames and Langley—NASA should pick one.

In merging corporate facilities, lose much of the unique individual corporate cultures.

Manufacturing technology needs to be examined - auto industry doing this.
- NASA Strategy - NASA should give up wind tunnels - virtual wind tunnels could be the alternative.
- Space program should be looked at.
- Center redundancies should be looked at.

- DOD and NASA combined a capabilities need to be evaluated so that the best of both could be shared.

NASA Aeronautics must be willing to give up some autonomy in exchange for greater funding and budgetary stability. Some freedom of choice could be relinquished. Some decision making could be shared to a much larger degree than it is now. These things would be given up to partners in the government or industry. These freedoms would be given up in exchange for a bigger role and stable budgets.

A dramatic change in process is also necessary in terms of the way budgets are allocated and research is conducted. For instance owning and managing all of the work facilities is not necessary. Would also be willing to be held more accountable in both the finance and promotion senses.

Priorities NASA AMES
- Center of Excellence for info techn - give up - stop the digging
- Invest in areas where have unique operational requirement get in where can make difference
- Too much overlap between centers - Ames/Langley facilities to support aero - use rather than support IT
- 20-30 percent downsizing - recommendations centered on where NASA center's rely on each other (DOD and NASA) better joint planning
- Believe should close "center" - do not downsize in place, they won't get rid of people - but will lose programs, totally predictable - must get at infrastructure - padlock and walk away, only reason to have the number of centers is history and politics

NASA should not do - improve tools to build aircraft. Should not be redundant with industry research.

NASA should give up duplicative business and where privatization can take place. Better, faster, cheaper without sacrificing safety!

- NASA culture change - stop non value added activities - travel.

NASA priorities - what they should not do, or give up.
Resources expended on the space shuttle. Give up operations - let industry do it.

NASA Strategy - Subsonic civil transport reduced priority. High speed computation research should not be in aeronautics.

Let the FAA do ATC
Agile aircraft should be military domain

Should increase not decrease aeronautics
But FAA should be doing ATC not NASA

NASA Aeronautics fills a role in R&D, applied research needs to fill a role in validating the investment

Priorities:
- flight centers—prototypes, new airplanes
- wind tunnel crisis—NASA has responsibility to develop world class wind tunnels. He's not a fan of the NASA-Boeing tunnel
- fundamental capabilities

- engines.

If NASA had to cut:

- base consolidation-but its a political time bomb.
- ATC—problem between NASA & FAA—ATC probably should be exclusively FAA.

NASA has too many centers. This causes overlap and competition for funding. However, NASA can not lose facilities, wind tunnels and research labs.
HST is a waste of money. There is not enough money in industry to build a HST. For NASA to pursue this technology, an industry consortium should come forward and request assistance in developing a HST.
Every time NASA has tried to develop a new vehicle type they have gotten them selves in trouble, NASP, they should concentrate on technologies, not vehicles.

NASA should not try and help specific manufacturers when they are involved in R&T. They should not be in the business of doing industry's R&D. AGATE work could fall into this category. Perpetuating old technology efforts should not be continued. Efforts that could be done by industry should not be done by NASA. HSCT should be NASAs.

Center redundancies should be carefully examined particularly from a cost viewpoint.

Pass subsonic research to industry. High risk research has to be done by government, low risk will be picked up by industry.

Give up little things, keep core.

Give up big flight demonstration programs
Focus on core technical areas
Coordinate with DoD

Reluctant to comment. NASA maintains the facilities for our industrial base and does the research that is pushing the edge and has a potential high pay off. NASA should get out of areas that industry could readily do on their own. The centers provide the infrastructure need by industry and they have been force due to cut backs to close labs that industry needs. At Ames, the air field could be closed; Dryden is the only place to do high risk flight test research; Langley, industry need access to the wind tunnels but research in the areas of human factors and simulation could be closed.

Nothing.
NASA has been working for years to develop better ways of doing research in the most effective manor. There must be a balance approach to maintain the quality of the country.

Not give up anything Outsource gargage
Can a consortium run NASA infrastructure?
Combine gov aero in one organization

Notes:

Industry is bullied by the fact that sales are up and they feel that they got to this point without the assistance of government. If they are satisfied to reap profit and not reinvest in future technologies they are going to be in trouble. Industry must prepare itself for a future possibly

without NASA. There is not a lot of interaction between military and civilian industry, there is going to be more work on this topic in the future.

Final comment: There is a lack of understanding of infrastructure and the role it plays on development of technology. NASA is not developing new test capabilities, we are dependent on current infrastructure. Other nation are developing new test beds and are rapidly catch up with us, to stay a world leader we need to invest in better infrastructure.

Prior to the start of the questions and during the explanation of the ground rules the responder took exception to the inclusion of "air breathing access to space" as a part of the aeronautics definition. It was felt this was a space venture that does not have the aeronautics industry support and will not be included in his answers.

In the future the present integrators will be dominant because the customers will not have the trust in the new players to purchase an entire system from them. The US will dominate because of their experience and market - supplier network. (Don't underestimate re: Japan and the auto industry)

Boeing envisions a 24 hour a day world wide company

Privatize NASA Aeronautics. Laboratory and simulation activities conducted by privatized NASA Aero and industry. Keep most research services in the government; with some new research contracts going to private industry.

A political and public climate was created by the Value Jet accident. There is no political leadership at present regarding the nation's aviation system. Tragedies came at an inopportune time because Congress is attempting to overhaul the industry because its an election year. The present political climate has the potential to adversely affect/influence the industry.
No mention of industry consolidation.
Economics of the airline industry: expensive business travel; continuous operation of the plane, cost is increasing because of increased safety demands. How important is cross-subsidizing?

Global external forces shaping future.

- High oil prices help rotorcraft industry, hurt airline business.
- US economic problems will seriously impact rotorcraft industry.
- Environmentalism was mentioned as a limited because of noise problems with higher tip speeds.
- All weather capability was also mentioned as a limiter because of availability issues

It was mentioned that high rotorcraft operating costs $1.50 per mile vs (airline) $.05 was one of the major industry problems.

NASA needs to take the aeronautics lead
American firms must share the R&D workload
    Lower end-short term by industry]
    Higher end-long term by NASA
Need Wind Tunnels
US needs new Infrastructure - still have 1930s airports/navaids